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October 9, 2014

Hand Delivery

Mr. Darrell Nitschke
Executive Director
NORTH DAKOTA PUBLIC
SERVICE COMMISSION
600 E. Boulevard Avenue, Dept. 408
Bismarck, ND 58505-0480

Dear Mr. Nitschke:

In re: Antelope Hills Wind Project, LLC
Site Certificate Application
Mercer County, North Dakota
Case No. PU-14-679

Enclosed for filing is one copy each of the following for the Antelope Hills Wind Energy Project:

1. Acoustic Analysis

2. Shadow Flicker Analysis

3. Replacement Pages 73-74 for CSC Application

4. Application Figures, reduced resolution

5. Application Figures, full resolution

Please call should you have any questions.

16 PU-14-679 Filed 10/09/2014 Pages: 75
Supplement to Application
Antelope Hills Wind Project, LLC
Brian Bjella, Crowley Fleck, PLLP

Very truly yours,

BRIAN R. BJELLA

bw
Enc.
cc: Mercer County Auditor

TETRA TECH

TO:	Infinity Wind Power
FROM:	Tetra Tech, Inc.
DATE:	October 6, 2014
PROJECT:	Antelope Hills Wind Energy Project
RE:	Revised Acoustic Screening Level Analysis

Tetra Tech has completed the following screening level acoustic assessment to determine the feasibility of the Antelope Hills Wind Project (Project) to operate within applicable noise criteria. Additionally, construction noise levels have been qualitatively assessed. The results of the acoustic analysis demonstrate that the Project would not exceed the State of North Dakota's regulatory limit for wind energy projects at any noise sensitive receptors (NSRs). This analysis is based on revised turbine locations provided on October 2, 2014.

Applicable Regulation

Tetra Tech completed a review of regulations and at the federal and local regulatory levels; there are no applicable noise regulations for the Project; however, the State provides regulatory limits that are applicable to the Project. North Dakota Chapter 69-06-08-01(4) provides the State's noise requirements with respect to wind energy projects:

> *"Additional avoidance areas for wind energy conversion facilities. A wind energy conversion facility site must not include a geographic area where, due to operation of the facility, the sound levels within one hundred feet of an inhabited residence or a community building will exceed fifty dBA. The sound level avoidance area criteria may be waived in writing by the owner of the occupied residence or the community building."*

Facility Construction Sound Levels

Project construction may cause short-term but unavoidable noise impacts. The sound levels resulting from construction activities vary significantly depending on several factors such as the type and age of equipment, the specific equipment manufacturer and model, the operations being performed, and the overall condition of the equipment and exhaust system mufflers. The list of construction equipment that may be used on the Project and estimates of near and far sound source levels are presented in Table 1. No blasting or pile driving is anticipated during Project construction.

Table 1. Estimated L_{max} Sound Pressure Levels from Construction Equipment

Equipment*	Estimated Sound Pressure Level at 50 feet (dBA)	Estimated Sound Pressure Level at 2000 feet (dBA)
Crane	85	53
Forklift	80	48
Backhoe	80	48
Grader	85	53
Man basket	85	53
Dozer	83 - 88	51 - 56
Loader	83 - 88	51 - 56
Scissor Lift	85	53
Truck	84	52
Welder	73	41
Compressor	80	48
Concrete Pump	77	45

Table 1. Estimated L_{max} Sound Pressure Levels from Construction Equipment

Equipment*	Estimated Sound Pressure Level at 50 feet (dBA)	Estimated Sound Pressure Level at 2000 feet (dBA)

Data compiled in part from the following sources:

Federal Highway Administration, "Roadway Construction Noise Model User's Guide," Report FHWA-HEP-05-054 / DOT-VNTSC-FHWA-05-01, January 2006.

Power Plant Construction Noise Guide, Bolt Beranek and Newman, Inc. 1977.

Federal Highway Administration, "Procedures for Abatement of Highway Traffic Noise and Construction Noise." Code of Federal Regulations, Title 23, Part 772, 1992.

Construction activity would also generate traffic having potential noise effects, such as trucks travelling to and from the site on public roads.

Sound generated by construction activities is generally exempt from the state noise regulation. Construction would be limited to daytime hours between 7 a.m. and 7 p.m. to the extent practicable and reasonable efforts would be made to minimize the impact of noise resulting from construction activities. The construction contractor would notify the community of the expected Project construction schedule and duration.

Facility Operational Sound Levels

Sound power level data are used in acoustic models to predict received sound pressure levels at observer locations. The proposed Project has a nameplate (gross) generating capacity of 172 megawatts (MW). Table 2 provides the three turbine types under consideration to achieve the nameplate capacity and the broadband sound power level associated with each.

All primary and alternative turbine locations were modeled; however, the actual number of turbines used for the final Project design would be less than that indicated in Table 2. For example, only 86 of the 92 Vestas V110 turbines modeled would be needed to achieve the 172MW nameplate capacity.

Table 2. Turbine Candidates and Layout Configurations

Turbine Model	Quantity	MW per Turbine	Hub Height (m)	Rotor Diameter (m)	Sound Power Level (dBA)*
Siemens SWT 2.3-108	92	2.3	80	108	108.0
Vestas V100-2.0	104	2.8	80	100	105.0
Vestas V110-2.0	92	2.0	80	110	107.5

*K-factors (or uncertainty factor) of 1.5 and 2 dBA were applied to the overall A-weighted sound power level of the Siemens and Vestas turbines, respectively.

Source: Siemens 2011, Vestas 2013, Vestas 2010

Turbine sound power levels are determined in accordance with IEC 61400-11, Wind Turbine Generator Systems—Part 11: "Wind turbine generator systems – Acoustic Noise Measurement Techniques". This methodology has been developed to allow for comparison between turbine manufacturers using consistent reporting and measurement techniques. The IEC test is an accepted standard providing a uniform methodology for measuring the noise emissions of a turbine from cut-in through full rotational wind speeds. The IEC testing standard defines deviation values σ_T, σ_R and σ_P for measured apparent sound power levels as described by IEC/TS 61400-14, where σ_T is the total standard deviation, σ_R is the standard deviation for test reproducibility, and σ_P is the standard deviation for product variation. To account for this inherent deviation associated with the IEC testing methodology, a confidence interval of k = 1.5 dBA and K = 2 dBA were applied to the broadband A-weighted turbine sound power level values for the Siemens and Vestas turbines, respectively. The combination of the modeling parameters used and the inclusion of the 1.5 or 2 dBA term are expected to result in a reasonable and conservative assessment of Project sound levels.

Sound power specifications and octave band frequency data were obtained by Infinity from the manufacturers of the turbines under consideration. It is assumed that the turbines for the Project would have similar sound power profiles as those used in the acoustic modeling analysis; however, it is possible that the final manufacturer warranty values may vary slightly. Table 3 provides a summary of the sound power data correlated by wind speed for each turbine model at reference rotor hub height assuming a roughness length[1] coefficient of 0.05 meters. As shown in Table 3, generally wind speeds lower than those corresponding to full rated power also result in lower sound levels.

Table 3. Turbine Broadband Sound Power Levels (dBA) Correlated with Wind Speed

Turbine Sound Power Level at Reference Wind Speed											
Wind Speed (m/s)	3	4	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10	11	12	13
Siemens SWT 2.3-	-	94.8	99.4	104.6	108.0	108.0	108.0	108.0	108.0	108.0	108.0
Vestas V100-2.0	93.8	96.0	100.1	103.9	105.0	105.0	105.0	105.0	105.0	105.0	105.0
Vestas V110-2.0	97.3	99.6	103.8	107.5	106.1	106.1	106.1	106.3	106.5	106.7	107.0

Source: Siemens 2011, Vestas 2013, Vestas 2010

The Project collector substation was not included in the acoustic analysis because setback distances to the nearest NSR are relatively large at approximately one mile and it is assumed that received sound levels would attenuate to low levels at the nearest NSRs. The Project substation would connect to a new 345kV transmission line which is evaluated in a separate acoustic technical memo that Tetra Tech has prepared for Infinity Wind Power.

Operational Acoustic Modeling Methodology

To assess the noise emission of a wind farm prior to construction and to estimate compliance status with permitting requirements, it is necessary to have prediction models with which a noise emission source level measured at a given reference point can be certified. A generally accepted approach for modeling a turbine as an idealized point source is described in the International Organization for Standardization (ISO) 9613-2, "Attenuation of Sound during Propagation Outdoors". The standard specifies methods to enable noise levels in the community to be predicted from sources of known sound emission and provides a summary of existing knowledge on outdoor sound. The calculation methodologies described in the standard are relied on by professionals in the field of acoustics.

Standard acoustic engineering methods conforming to ISO 9613-2 were incorporated into the Project acoustic modeling analysis using DataKustic GmbH's CadnaA, the computer-aided noise abatement program (v 4.4.145). The engineering methods specified in this standard consist of full octave band algorithms that incorporate geometric spreading due to wave divergence, reflection from surfaces, atmospheric absorption, screening by topography and obstacles, ground effects, source directivity, heights of sources and receptors, seasonal foliage effects, and meteorological conditions. Operational broadband sound pressure levels were calculated assuming that all turbines inclusive of the alternates are operating continuously and concurrently at the maximum manufacturer-rated sound level. The sound energy was then summed to determine the equivalent continuous A-weighted downwind sound pressure level at a given point of reception such as a NSR.

Topographical information was imported into the acoustic model using the official U.S. Geological Survey (USGS) digital elevation dataset to accurately represent terrain in three dimensions. Terrain conditions, vegetation type, ground cover, and the density and height of foliage can also influence the absorption that takes place when sound waves travel over land. The ISO 9613-2 standard accounts for

[1] The roughness length describes the change in wind speed at increased elevation and may vary based on site specific terrain conditions.

ground absorption rates by assigning a numerical coefficient of G=0 for acoustically hard, reflective surfaces and G=1 for absorptive surfaces and soft ground. In this case, the Project area agricultural lands used for cultivation are assumed to be moderately reflective and therefore a ground absorption factor of G=0.5 was applied. Sound attenuation through foliage and diffraction around and over existing structures such as buildings was ignored under all acoustic modeling scenarios. Sound attenuation by the atmosphere is not strongly dependent on temperature and humidity; however, a temperature of 10°C (50°F) and a relative humidity of 70 percent were selected as reasonably representative of conditions favorable to sound propagation.

Inherent to the ISO 9613-2 and IEC61400-11 standards are downwind conditions. That is, the turbine sound power levels and modeling methods are representative of when the wind is blowing from the turbine to the receptor. In fact, the ISO 9613-2 modeling method unrealistically assumes that downwind conditions exist in all directions, between each turbine and each receptor simultaneously, even though that is physically impossible. Therefore, lower levels are expected in the upwind direction. Conversely, there may be meteorological conditions from time to time that may aid in the long range propagation of sound. These anomalous meteorological conditions may include wind gradients that bend sound downwards, which principally affect long range sound propagation. Received sound levels during anomalous meteorological conditions were also estimated using a range dependent correction factor.

Sound power levels were modeled at each NSR within the Project Area and a one-mile buffer area. Potential NSRs were identified based on the North Dakota standard quoted above as occupied residences or community buildings. Within the Project Area 38 potential NSRs were identified. All were residences, and included those known to be occupied and those whose status as occupied or unoccupied was not known.

<u>Operational Acoustic Modeling Results</u>

To determine compliance with the State's noise regulation acoustic modeling was completed for Project operation for two cases: (1) highest specified operational sound level according to the turbine manufacturer's specifications under typical downwind propagation conditions; and (2) highest specified operational sound level according to the turbine manufacturer's specifications under anomalous meteorological conditions. Noise was modeled at a distance of 100 feet from each residential structure in consideration of the North Dakota noise standard quoted above.

The acoustic modeling results were compared to the State's numerical limits of 50 dBA. Table 4 summarizes the number of NSRs within selected sound pressure level ranges (in dBA) under each of the modeled operational conditions. The tabulated results are independent of the existing acoustic environment (i.e. are representative of expected Project-generated sound levels only). Table A-1 (Attachment 1) presents the received sound levels at each of the 38 individual NSRs for each turbine type by receptor ID and UTM coordinates. The assessment included prediction and plotting of sound level contours from the Project. Sound contour maps displaying the corresponding typical downwind and anomalous meteorological operational sound levels in color-coded isopleths are presented in Figures 1 to 6 (Attachment 1). Isopleths are projected onto scaled aerial photographs at a height of 1.52 meters (5 feet) above grade i.e., at the approximate height of a person's ears while standing. In conclusion, modeling results, as shown in Tables 4 and A-1, indicate that the Project would not exceed the applicable State noise limits for wind energy projects at any NSRs.

Table 4. Number of NSRs by Sound Level Range and Exceedance Condition for each Turbine Layout

Sound Level Range (dBA)	Siemens SWT 2.3-108		Vestas V100-2.0		Vestas V110-2.0	
	Typical Downwind	Anomalous Meteorological	Typical Downwind	Anomalous Meteorological	Typical Downwind	Anomalous Meteorological
Less than 35	11	6	18	14	11	5
35 - 40	10	10	6	8	10	11
40 - 45	7	10	8	10	7	10
45-50	10	12	6	6	10	12
50-55+	0	0	0	0	0	0
>50 (North Dakota Limit)	0	0	0	0	0	0

ATTACHMENT 1

Tabulated Results and Sound Contour Figures

Table A-1. Tabulated Acoustic Modeling Results

NSR ID	UTM Coordinates (m)		Sound Levels (dBA L_{eq}) Siemens SWT 2.3-108		Sound Levels (dBA L_{eq}) Vestas V100-2.0		Sound Levels (dBA L_{eq}) Vestas V110-2.0	
	Easting	Northing	Typical Downwind	Anomalous Meteorological	Typical Downwind	Anomalous Meteorological	Typical Downwind	Anomalous Meteorological
1	731437	5255350	45	46	42	43	45	46
2	731508	5251629	39	41	37	38	39	41
3	731684	5252901	43	44	40	41	43	44
4	727710	5252234	43	44	40	41	43	44
5	728422	5255087	49	50	47	47	49	50
6	727193	5251180	37	39	35	37	38	40
7	725499	5254654	48	48	45	45	48	48
8	724089	5255508	50	50	46	47	50	50
9	721931	5254703	43	44	43	44	43	44
10	722548	5253758	46	46	43	44	46	46
11	721603	5258460	43	44	39	40	43	44
12	721875	5260187	35	37	31	34	35	38
13	721768	5260539	32	34	28	30	33	35
14	719590	5259774	39	41	35	37	40	41
15	718419	5260217	39	41	35	37	39	41
16	717332	5254867	40	41	37	38	40	41
17	716563	5259406	48	48	46	46	48	48
18	716778	5260862	40	41	38	39	40	41
19	714673	5259316	49	49	46	46	49	49
20	714980	5253990	36	38	33	35	36	38
21	713395	5256469	38	40	35	37	39	40
22	721131	5255792	49	50	46	46	49	50
23	728353	5256210	47	47	43	44	47	47
24	727751	5256373	45	46	41	42	45	46
25	731064	5256591	36	37	32	34	36	37
26	726863	5258471	36	38	32	35	36	38
27	728259	5258682	35	37	32	34	35	38
28	728358	5259438	33	36	31	33	35	37
29	729774	5258950	30	32	26	29	30	32
30	731342	5257954	34	36	31	33	35	37
31	736027	5252884	21	23	18	21	22	24
32	735517	5249601	22	24	20	23	23	26
33	734475	5249461	23	25	21	23	24	26
34	731806	5253536	44	45	43	44	44	45
35	729522	5251697	47	48	46	46	47	48

Table A-1. Tabulated Acoustic Modeling Results

NSR ID	UTM Coordinates (m)		Sound Levels (dBA L_{eq}) Siemens SWT 2.3-108		Sound Levels (dBA L_{eq}) Vestas V100-2.0		Sound Levels (dBA L_{eq}) Vestas V110-2.0	
	Easting	Northing	Typical Downwind	Anomalous Meteorological	Typical Downwind	Anomalous Meteorological	Typical Downwind	Anomalous Meteorological
36	732207	5250969	34	37	32	34	35	37
37	733070	5251261	32	35	30	33	33	36
38	727161	5256975	47	47	43	43	47	47

Antelope Hills Wind Project
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Certificate of
Site Compatibility

Figure 1
Operational Leq Sound
Levels under Typical
Downwind Conditions
– Siemens SWT 2.3-108

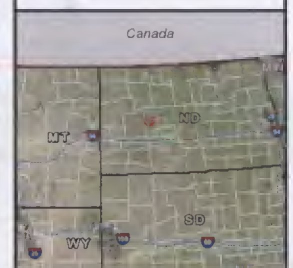
Mercer County, ND
October 2014

- State Highway
- Minor Road
- Project Area
- Turbine Location*
- Alternate Turbine Location*
- Interconnection Line
- Proposed Substation
- Residences
- North Dakota Limit 50 dBA

Sound Isopleths (dBA)

- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60 or greater

*The Project would utilize up to 75 Siemens SWT Turbines; however, 92 potential Siemens turbine locations are included on this figure to account for alternate locations that may be used.



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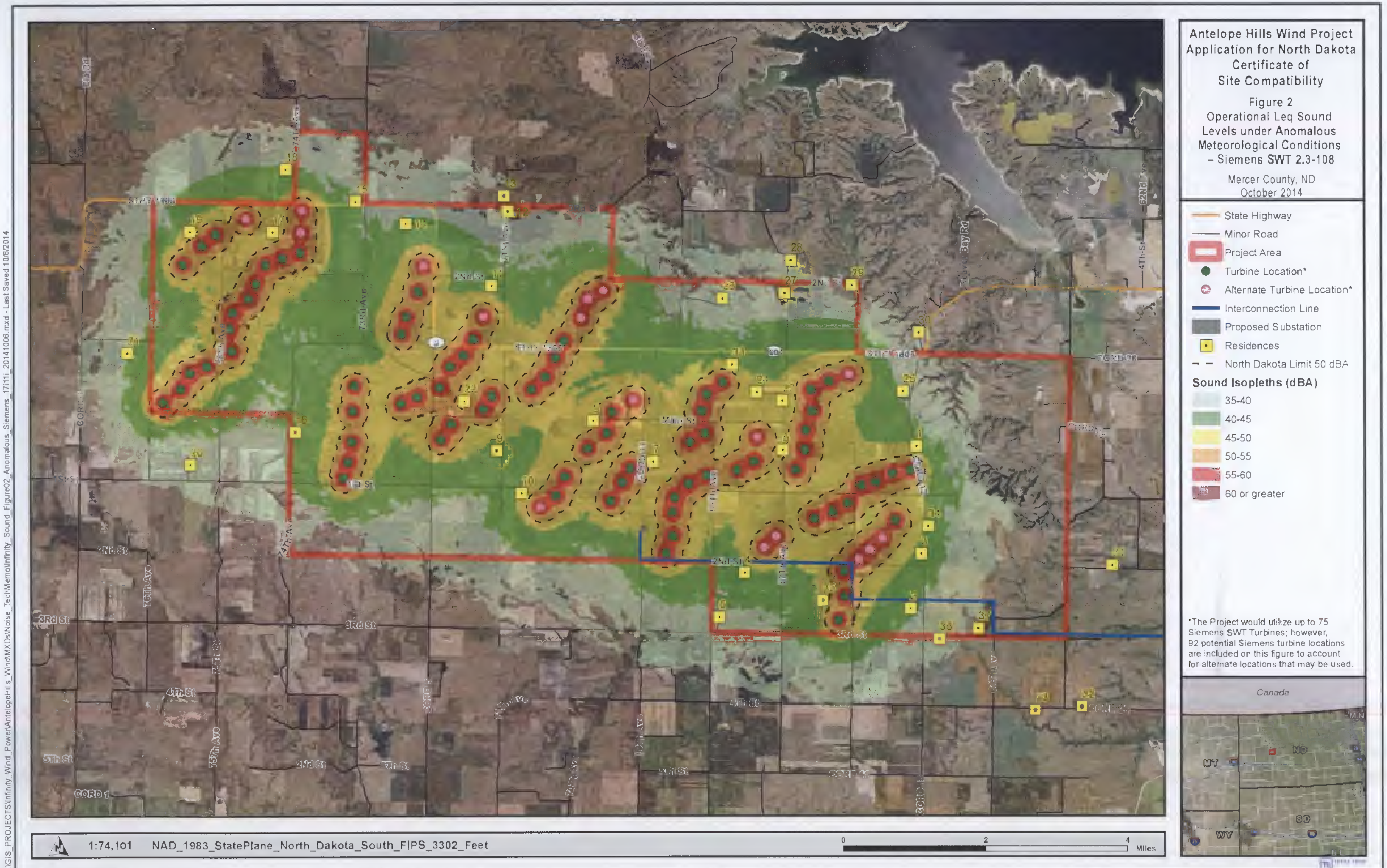

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Antelope Hills Wind Project Application for North Dakota Certificate of Site Compatibility

Figure 3
Operational Leq Sound Levels under Typical Downwind Conditions – Vestas V100-2.0

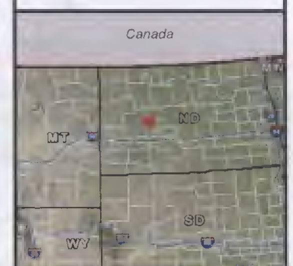
Mercer County, ND
October 2014

- State Highway
- Minor Road
- Project Area
- Turbine Location*
- Alternate Turbine Location*
- Interconnection Line
- Proposed Substation
- Residences
- North Dakota Limit 50 dBA

Sound Isopleths (dBA)

- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60 or greater

*The Project would utilize up to 86 Vestas V100 Turbines; however, 105 potential Vestas turbine locations are included on this figure to account for alternate locations that may be used.



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Antelope Hills Wind Project Application for North Dakota Certificate of Site Compatibility

Figure 4
Operational Leq Sound Levels under Anomalous Meteorological Conditions – Vestas V100-2.0

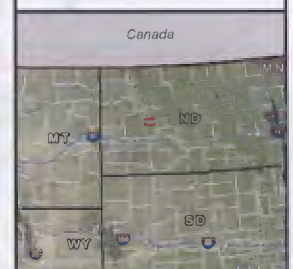
Mercer County, ND
October 2014

- State Highway
- Minor Road
- Project Area
- Turbine Location*
- Alternate Turbine Location*
- Interconnection Line
- Proposed Substation
- Residences
- North Dakota Limit 50 dBA

Sound Isopleths (dBA)

- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60 or greater

*The Project would utilize up to 86 Vestas V100 Turbines; however, 105 potential Vestas turbine locations are included on this figure to account for alternate locations that may be used.



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0 2 4 Miles

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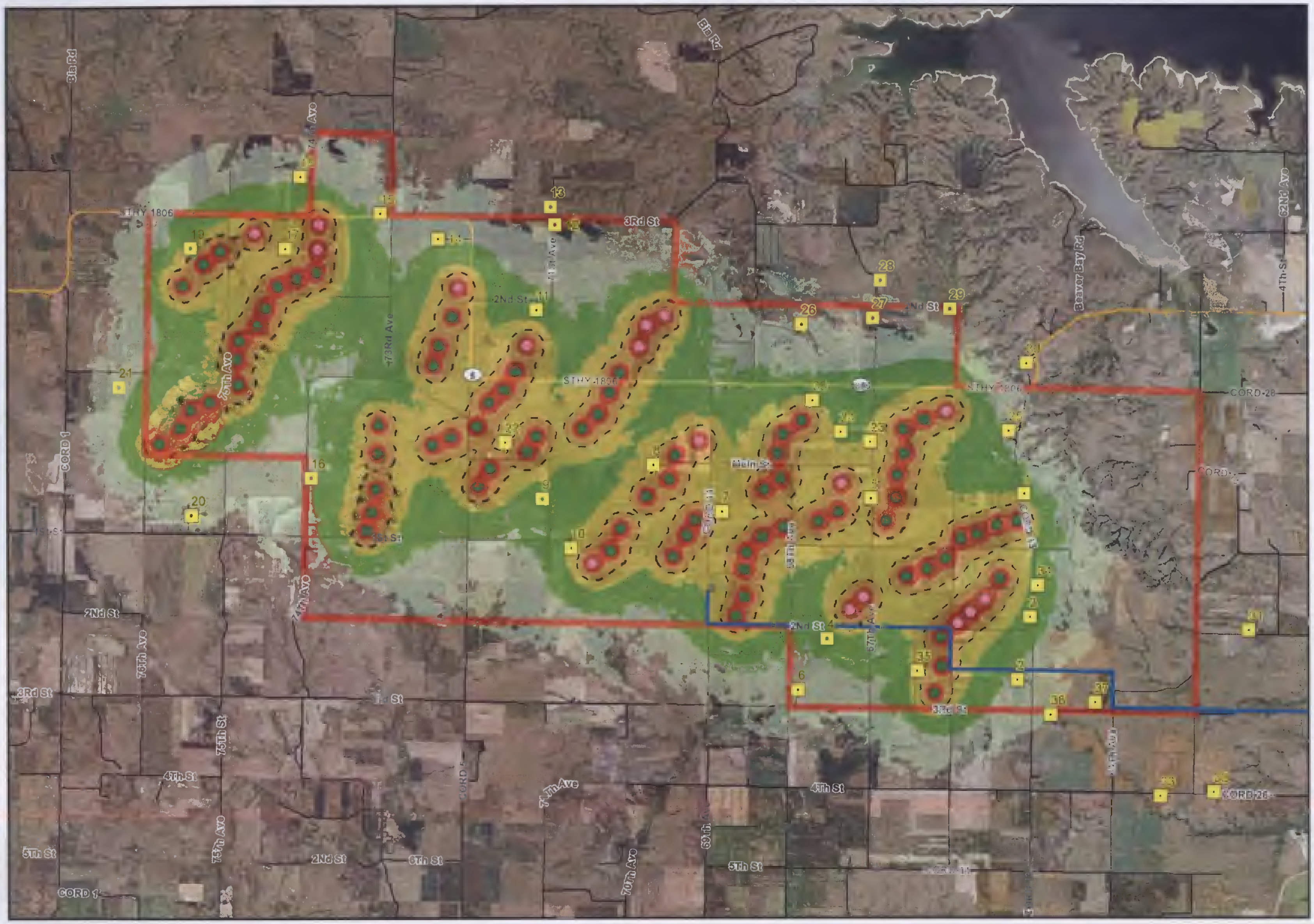


Antelope Hills Wind Project
Application for North Dakota
Certificate of
Site Compatibility

Figure 5
Operational Leq Sound
Levels under Typical
Downwind Conditions
– Vestas V110-2.0

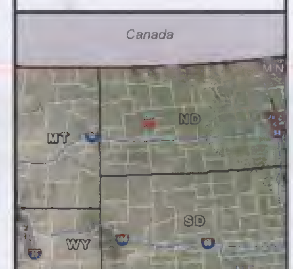
Mercer County, ND
October 2014

- State Highway
- Minor Road
- Project Area
- Turbine Location*
- Alternate Turbine Location*
- Interconnection Line
- Proposed Substation
- Residences
- North Dakota Limit 50 dBA

Sound Isopleths (dBA)

- 35-40
- 40-45
- 45-50
- 50-55
- 55-60
- 60 or greater

*The Project would utilize up to 86 Vestas V110 Turbines; however, 92 potential Vestas turbine locations are included on this figure to account for alternate locations that may be used.



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0 2 4 Miles

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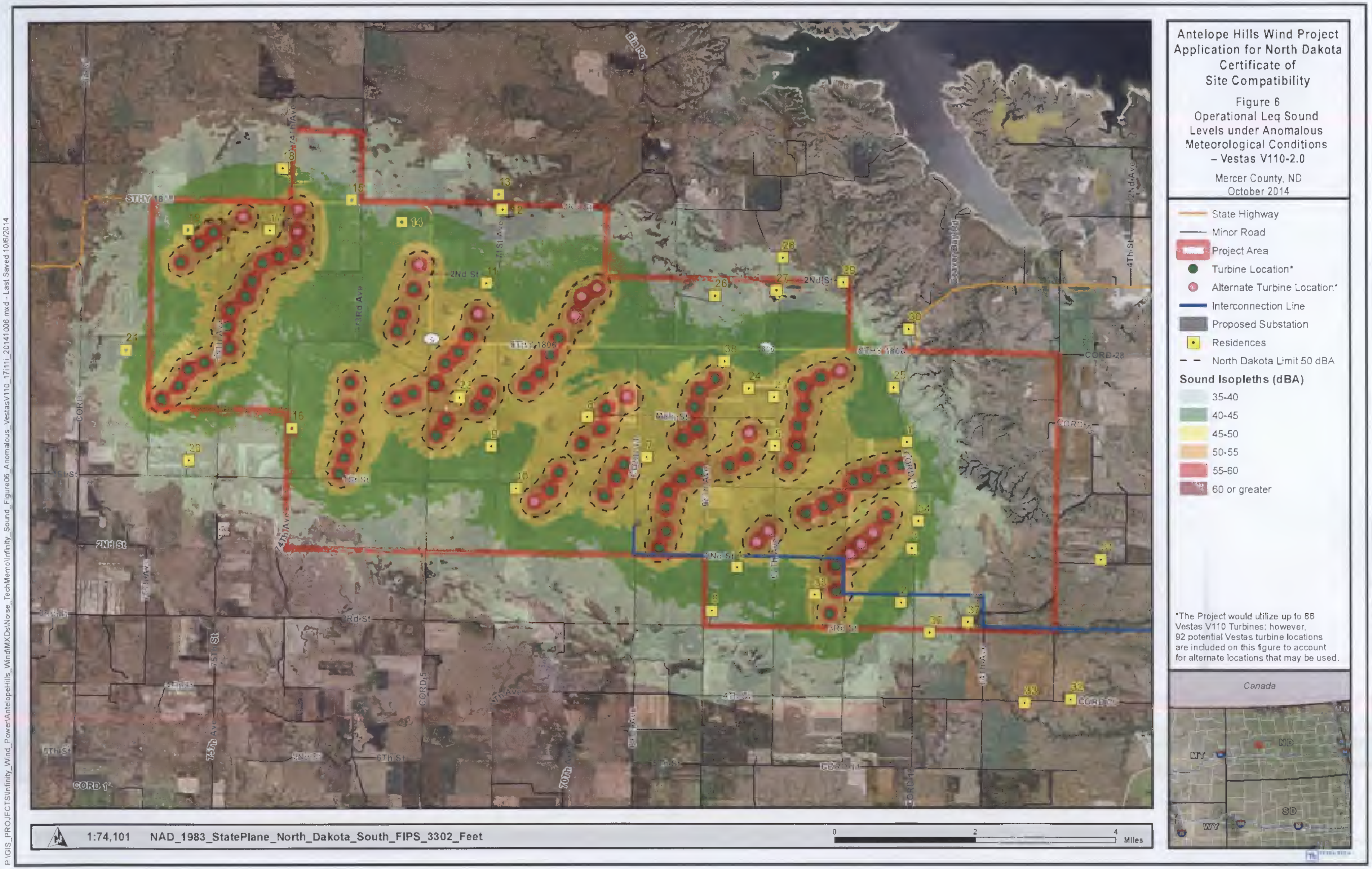

Antelope Hills Wind Project
Application for North Dakota Certificate of Site Compatibility
Figure 6
Operational Leq Sound Levels under Anomalous Meteorological Conditions – Vestas V110-2.0
Mercer County, ND
October 2014
State Highway
Minor Road
Project Area
Turbine Location*
Alternate Turbine Location*
Interconnection Line
Proposed Substation
Residences
North Dakota Limit 50 dBA
Sound Isopleths (dBA)
35-40
40-45
45-50
50-55
55-60
60 or greater
*The Project would utilize up to 86 Vestas V110 Turbines; however, 92 potential Vestas turbine locations are included on this figure to account for alternate locations that may be used.
Canada
ND
SD
MT
WY
1:74,101
NAD_1983_StatePlane_North_Dakota_South_FIPS_3302_Feet
0
2
4
Miles

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5.10.2 Potential Impacts

Project construction may cause short-term but unavoidable noise impacts due types of construction and equipment. Construction activity would also generate traffic that would have potential noise effects, such as trucks travelling to and from the site on public roads. Sound generated by construction activities is generally exempt from state and local noise regulation. Once the Project has been built, no significant noise impacts are anticipated from regular maintenance.

A screening level acoustic assessment was conducted to determine the feasibility of the Project to operate within applicable noise criteria (Appendix A). The assessment is representative of worse-case scenario because the Project layout includes more than the target number of turbine locations needed to meet the Project's nameplate capacity to account for alternate locations. Noise was modeled at a distance of 100 feet from each residential structure in consideration of the North Dakota noise standard. The acoustic modeling results were compared to the State's numerical limits of 50 dBA. Table 22 summarizes the number of noise sensitive receptors within selected sound pressure level ranges (in dBA) under each of the modeled operational conditions.

Table 22. Number of Noise Sensitive Receptors by Sound Level Range and Exceedance Condition for each Wind Turbine Layout

Sound Level Range (dBA)	Siemens 2.3-108		Vestas V-100		Vestas V-110	
	Typical Downwind	Anomalous Meteorological	Typical Downwind	Anomalous Meteorological	Typical Downwind	Anomalous Meteorological
Less than 35	11	6	18	14	11	5
35 – 40	10	10	6	8	10	11
40 - 45	7	10	8	10	7	10
45-50	10	12	6	6	10	12
50-55+	0	0	0	0	0	0
>50 (North Dakota Limit)	0	0	0	0	0	0

The results of the acoustic assessment demonstrate that the Project would comply with regulatory limits and/or guidelines at all noise sensitive receptors.

<u>**Potential Noise Impacts to Wildlife**</u>

Although it is likely that construction of the Project will result in short-term disturbance of wildlife, it will be difficult to assess whether the disturbance comes from the noise of construction activities or the activities themselves (e.g., construction vehicles moving along roads). All such activities will be short-term and limited to the period of construction. Available research regarding the noise impacts of wind farm operations suggests that animals in the area would either habituate to consistent low-frequency noise from the turbines or would alter their behaviors to adapt to the new acoustic environment (e.g., Rabin et al. 2003, Brumm and Slabbekoorn 2005, Wood and Yezerinac 2006)

5.10.3 Mitigative Measures

Antelope will implement BMPs and mitigation measures applicable to noise as follows:

- Take advantage of topography and the distance to nearby sensitive receptors when positioning potential sources of noise.
- Select equipment with the lowest noise levels available and no prominent discrete tones, when possible.
- Maintain all equipment in good working order in accordance with manufacturer specifications. Suitable mufflers and/or air-inlet silencers should be installed on all internal combustion engines and certain compressor components.
- All vehicles traveling within and around the project area should operate in accordance with posted speed limits.
- Establish a process for documenting, investigating, evaluating, and resolving project-related noise complaints.

BMPs and mitigation measures applicable during construction include the following:

- Limit noisy construction activities to the least noise-sensitive times of day (daytime only, between 7 a.m. and 7 p.m.) and weekdays.
- Schedule noisy activities to occur at the same time whenever feasible, since additional sources of noise generally do not greatly increase noise levels at the site boundary. Less-frequent but noisy activities would generally be less annoying than lower-level noises occurring more frequently.
- Locate stationary construction equipment (e.g., compressors or generators) as far as practical from nearby sensitive receptors.
- In the unlikely event that blasting or pile driving would be needed during the construction period, notify nearby residents in advance.

The same BMPs and mitigation measures applicable to construction activities are applicable to decommissioning activities.

5.11 Cultural, Historical, and Architectural Resources

Cultural resources include archeological sites, historic standing structures, objects, districts, traditional cultural properties and other properties that illustrate important aspects of prehistory or history or have important and long-standing cultural associations with established communities or social groups. Significant archeological and architectural properties are usually defined by eligibility criteria for listing in the National Register of Historic Places (NRHP), and in consultation with the State Historic Preservation Office (SHPO).

Shadow Flicker Impact Analysis for the Antelope Hills Wind Energy Project

Mercer County, North Dakota

Prepared for

Antelope Hills Wind Project, LLC

Prepared by

TETRA TECH

Tetra Tech, Inc.

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Boston, Massachusetts 02110

August 2014

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complex world CLEAR SOLUTIONS™

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1.0 OVERVIEW

Antelope Hills Wind Project, LLC (Antelope), is proposing to develop the Antelope Hills Wind Energy Project (Project) in Mercer County, North Dakota. The Project would install up to 86 wind turbines with a maximum nameplate capacity of 172 MW, with the number of turbines depending on the size and model of turbine used. Tetra Tech has conducted the following shadow flicker analysis for the Project to support the Project's application for a Certificate of Site Compatibility under the North Dakota regulations. This analysis is based on revised turbine locations provided on October 2, 2014.

2.0 PROJECT COMPONENTS

The wind turbine models being considered for the Project, and evaluated for potential shadow flicker impacts, have the following characteristics:

- **Vestas 2.0 V-110** – 3-blade 110-meter diameter rotor, with a hub height of 80 meters. The Vestas 2.0 V-110 has a normal high rotor speed of approximately 14.9 rotations per minute (rpm) which translates to a blade pass frequency of 0.75Hertz (Hz) which is less than 1 alternation per second. Although 92 Vestas turbines are included in this impact analysis to account for alternate locations that may be used, a maximum of 86 of these turbines would be constructed.

- **Vestas 2.0 V-100** – 3-blade 100-meter diameter rotor, with a hub height of 80 meters. The Vestas 2.0 V-100 has a normal high rotor speed of 14.9 rpm which translates to a blade pass frequency of 0.75 Hz (less than 1 alternation per second). Although 104 Siemens turbines are included in this impact analysis to account for alternate locations that may be used, a maximum of 86 of these turbines would be constructed.

- **Siemens 2.3/108** - 3-blade, 108-meter diameter rotor, with a hub height of 80 meters. The Siemens 2.3/108 has a normal high rotor speed of approximately 16 rpm which translates to a blade pass frequency of 0.80 Hz (less than 1 alternation per second). The Siemens turbine layout uses the identical locations as the Vestas V-110, however only 75 of the 92 locations would be used. Since the V-110 is slightly larger, the analysis should be applicable to the Siemens 2.3/108 turbine as well.

The shadow flicker impact analysis considered both the primary and alternative turbine locations, which represent 6, 17 or 18 more turbines than will be constructed for the Vestas V-110, Siemens 2.3/108 and Vestas V-100 scenarios. Figure 1 shows the proposed turbine locations, along with the potential receptor locations in the project area. All potential receptors are residences, either occupied or with occupation status unknown.

3.0 SHADOW FLICKER BACKGROUND

A wind turbine's moving blades can cast a moving shadow on locations within a certain distance of a turbine. These moving shadows are called shadow flicker, and can be a temporary phenomenon experienced at nearby residences or public gathering places. The impact area depends on the time of year and day (which determine the sun's azimuth and altitude angles) and the wind turbine's physical characteristics (height, rotor diameter, blade width, and orientation of the rotor blades). Shadow flicker impact to surrounding properties generally occurs during low angle sunlight conditions, typically during sunrise and sunset times of the day. However, when the sun angle gets very low (less than 3 degrees), sunlight passes through more atmosphere and becomes too diffused to form a coherent shadow. Shadow flicker will not occur when the sun is obscured by clouds or fog, at night, or when the source turbine(s) are not operating. In addition, shadow flicker is only an issue when at least 20% of the sun's disc is covered by the turbine blades.

Shadow flicker intensity is defined as the difference in brightness at a given location in the presence and absence of a shadow. Shadow flicker intensity diminishes with greater receptor-to-turbine separation distance. Shadow flicker intensity for receptor-to-turbine distances beyond 2,500 meters (8,202 feet) is very low and generally considered imperceptible. In general, increasing proximity to turbines may make shadow flicker more noticeable, with the largest number of shadow flicker hours, along with greatest shadow flicker intensity, occurring nearest the wind turbines.

Shadow flicker frequency is related to the wind turbine's rotor blade speed and the number of blades on the rotor. From a health standpoint, the low flicker frequencies associated with wind turbines are harmless, and public concerns that flickering light from wind turbines can have negative health effects such as triggering seizures in people with epilepsy are unfounded. Epilepsy Action (working name for the British Epilepsy Foundation) states that there is no evidence that wind turbines can cause seizures (Epilepsy Action 2008). However, they recommend that wind turbine flicker frequency be limited to 3 Hz. (For comparison, strobe lights used in discotheques have frequencies which range from about 3 Hz to 10 Hz (1 Hz = 1 flash per second). Since the proposed Project's wind turbine blade pass frequency is approximately 0.75 Hz (less than 1 alternation per second), no negative health effects to individuals with photosensitive epilepsy are anticipated.

Shadow flicker impacts are not regulated in applicable state or federal law, and there is no permitting threshold with regard to hours per year of anticipated impacts to a receptor from a wind energy project.

4.0 WINDPRO SHADOW FLICKER ANALYSIS

An analysis of potential shadow flicker impacts from the Project was conducted using the WindPro software package. The turbine array provided by Antelope (layout dated August 7, 2014), which includes up to 104 turbine locations, was included in the analysis. The analysis evaluated the following two turbine scenarios:

- Scenario A – 92 Vestas 2.0 V-110 turbines (only 86 of these turbines would be constructed)
- Scenario B – 104 Vestas 2.0 V-100 turbines (only 86 of these turbines would be constructed)

  Scenario C – 92 Siemens 2.3/108 turbines (only 75 of these turbines would be constructed). The locations of the Siemens turbines are identical to those for the Vestas V-110

The potential locations of the Siemens 2.3/108 turbine type are identical to the Vestas V-110, however only 75 turbines would be used as opposed to 86 for the Vestas. The Siemens turbine has identical specifications as the Vestas V-110 except that the rotor blades are slightly shorter (108 m vs 110 m). The shadow flicker impact of the Siemens turbine is expected to be slightly less. The results of the V-110 shadow flicker analysis are applicable to the Siemens turbine.

The WindPro analysis was conducted to determine shadow flicker impacts under realistic impact conditions (actual expected shadow). This analysis calculated the total amount of time (hours and minutes per year) that shadow flicker could occur at receptors surrounding the project. The realistic impact condition scenario is based on the following assumptions:

- The elevation and position geometries of the wind turbines and surrounding receptors (potentially occupied residences). Elevations were determined using United States Geological Survey (USGS) digital elevation model (DEM) data. Positions geometries were determined using geographic information system (GIS) and referenced to Universal Transverse Mercator (UTM) Zone 13 (NAD83).
- The position of the sun and the incident sunlight relative to the wind turbine and receptors on a minute-by-minute basis over the course of a year.
- Historical sunshine availability (percent of total hours available). Historical sunshine rates for the area (as summarized by the National Climatic Data Center (NCDC 2008) for nearby Bismarck, North Dakota) used in this analysis are as follows:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
53%	53%	58%	58%	61%	64%	73%	72%	65%	58%	43%	47%

- Estimated wind turbine operations and orientation (based on approximately 4 years (June 2010 – July 2014) of wind data, including wind speed / wind direction frequency distribution, measured at on-site meteorological towers).

- Receptor viewpoints (i.e., house windows) are assumed to always be directly facing turbine to sun line of sight ("greenhouse mode").

WindPro incorporates terrain elevation contour information and the analysis accounts for terrain elevation differences. The sun's path with respect to each turbine location is calculated by the software to determine the cast shadow paths every minute over a full year. Sun angles less than 3 degrees above the horizon were excluded, for the reasons identified earlier in this section. Since shadow flicker is only noticeable when at least 20% of the sun disc is covered by the blades, WindPro uses blade width dimension data to calculate the maximum distance from the turbine where shadow flicker would be a potential impact.

It should be noted however, that WindPro provides a conservative estimate of shadow flicker as obstacles such as trees, haze, and visual obstructions (window facing, coverings) are not fully accounted despite the likelihood of their reducing or eliminating shadow flicker impacts to receptors. A total of 38 receptor locations were identified within approximately one mile of proposed Project turbines. A receptor in the model is defined as a 1 meter squared area (approximate size of a typical window), 1 meter (3.28 feet) aboveground level. Approximate eye level is set at 1.5 meters (4.94 feet). Figure 1 shows the receptor locations and proposed Project turbines considered for Scenarios A and B.

Because the Project is using a minimum turbine siting setback requirement of 1,320 feet (402 meters) to occupied residences, the most sensitive receptors are generally not located in the high potential shadow flicker impact zones.

5.0 SHADOW FLICKER ANALYSIS RESULTS

As expected, WindPro predicts that shadow flicker impacts will be greatest at locations nearer to the wind turbines. Figures 2A and 2B describe the WindPro predicted shadow flicker impact areas for turbine Scenarios A and B, respectively. A detailed WindPro shadow flicker analysis summary, for each of the modeled receptor location, is provided in Attachment A.

Tables 1A and 1B present the WindPro predicted shadow flicker impacts for the ten receptors with the greatest total annual shadow flicker impact for each of the two turbines modelled. Considering all turbine scenarios, only 9 of the 38 receptors modeled had expected shadow flicker impacts of more than 30 hours per year; and all of these receptors are project participants.. The maximum predicted shadow flicker impact at any residence receptor is 66 hours 13 minutes per year (Receptor 8), which is approximately 1.5 percent of the potential available daylight hours.

Table 1A. WindPro Predicted Shadow Flicker Impacts for Receptors with Maximum Expected Impacts – Turbine Scenario A (92 Vestas 2.0 V-110 Turbines)

Receptor ID*	Expected Shadow Flicker [hh:mm / year]	Project Participation Status
8	67:12:00	Yes
5	63:03:00	Yes
22	54:54:00	Yes
19	49:42:00	Yes
17	42:18:00	Yes
7	40:51:00	Yes
23	34:25:00	Yes
35	33:40:00	Yes
10	33:10:00	Yes
24	25:49:00	Yes

Table 1B. WindPro Predicted Shadow Flicker Impacts for Receptors with Maximum Expected Impacts – Turbine Scenario B (104 Vestas 2.0 V-100 Turbines)

Receptor ID*	Expected Shadow Flicker [hh:mm / year]	Project Participation Status
5	51:47:00	Yes
8	48:08:00	Yes
22	46:22:00	Yes
35	39:00:00	Yes
10	36:58:00	Yes
7	35:40:00	Yes
17	31:21:00	Yes
23	29:27:00	Yes
19	29:08:00	Yes
34	25:11:00	No

The shadow flicker impact prediction statistics are summarized in Tables 2A and 2B.

Table 2A. Statistical Summary of WindPro Predicted Shadow Flicker Impacts at Modeled Receptor Locations – Turbine Scenario A (92 Vestas 2.0 V-110 Turbines)

Cumulative Shadow Flicker Time (expected)	Number of Receptors
Total	38
= 0 Hours	18
> 0 Hours < 10 Hours	4
≥ 10 Hours < 20 Hours	6
≥ 20 Hours < 30 Hours	1
≥ 30 Hours	9

Table 2B. Statistical Summary of WindPro Predicted Shadow Flicker Impacts at Modeled Receptor Locations – Turbine Scenario B (104 Vestas 2.0 V-100)

Cumulative Shadow Flicker Time (expected)	Number of Receptors
Total	38
= 0 Hours	19
> 0 Hours < 10 Hours	5
≥ 10 Hours < 20 Hours	2
≥ 20 Hours < 30 Hours	5
≥ 30 Hours	7

The slightly higher shadow flicker impacts for Scenario A (Vestas V-110 turbines), can be explained by the longer blades for this turbine. Note that although 92 to 104 turbines were assessed with WindPro, depending on the turbine model, only 86 of these turbines would actually be constructed.

6.0 CONCLUSION

The analysis of potential shadow flicker impacts from the Project on nearby receptors shows that shadow flicker impacts within the area of study are expected to be minor and shadow flicker is not expected to be a significant environmental impact. All of the residential receptors with the highest shadow flicker hours are owned by participating landowners, with land under lease to Antelope, and have agreements with Antelope providing allowance for such potential nuisance issues.

The analysis was deliberately conservative and actual shadow flicker is expected to occur for less than the modeled durations. The analysis assumes that the receptors all have a direct in-line view of the incoming shadow flicker sunlight and does not account for trees or other obstructions which may block sunlight. In reality, the windows of many houses will not face the sun directly for the key shadow flicker impact times. Adding to the analysis' conservatism, Antelope will construct fewer turbines than were modeled.

7.0 REFERENCES

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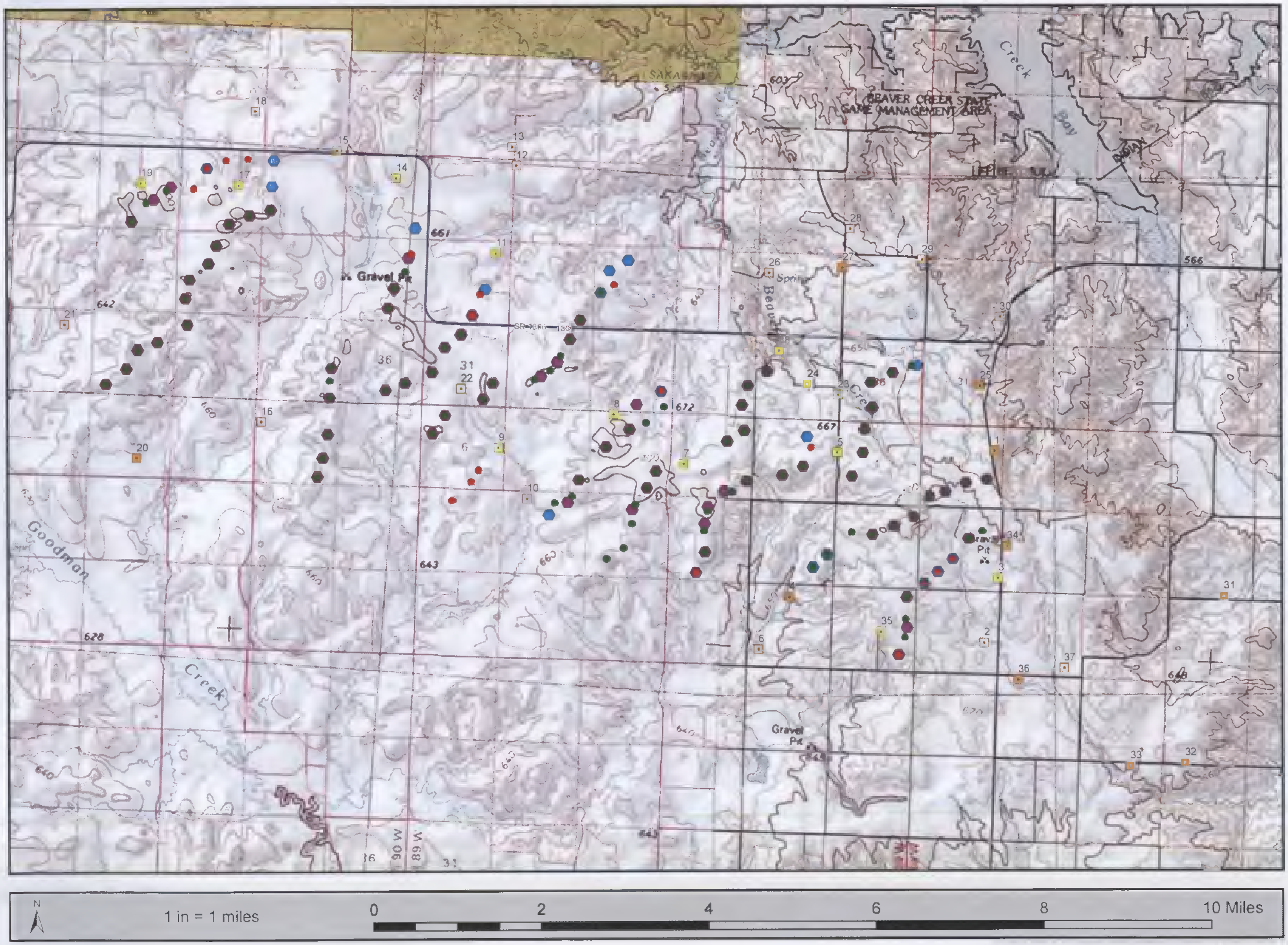
National Climatic Data Center (NCDC). 2008. Sunshine Average Percent of Possible. http://www.ncdc.noaa.gov/oa/climate/online/ccd/pctpos.txt. Accessed 3/1/10

WindPower. 2003. Danish Wind industry Association. Shadow Casting From Wind Turbines. http://guidedtour.windpower.org/en/tour/env/shadow/index.htm, Accessed 4/28/10

FIGURES



Antelope Hills Wind Energy Project

Figure 1: Receptors Modeled with WindPro to Predict Potential Shadow Flicker Imapcts

October 2014

Legend

Vestas 2.0 V-100 Turbine

- Primary Turbine Location
- Alternate Turbine Location

Vestas 2.0 V-110 Turbine

- Primary Turbine Location
- Alternate Turbine Location

Receptor

- Non-Participating
- Participating
- Secondary State and County Road

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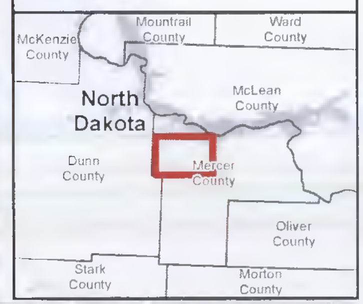

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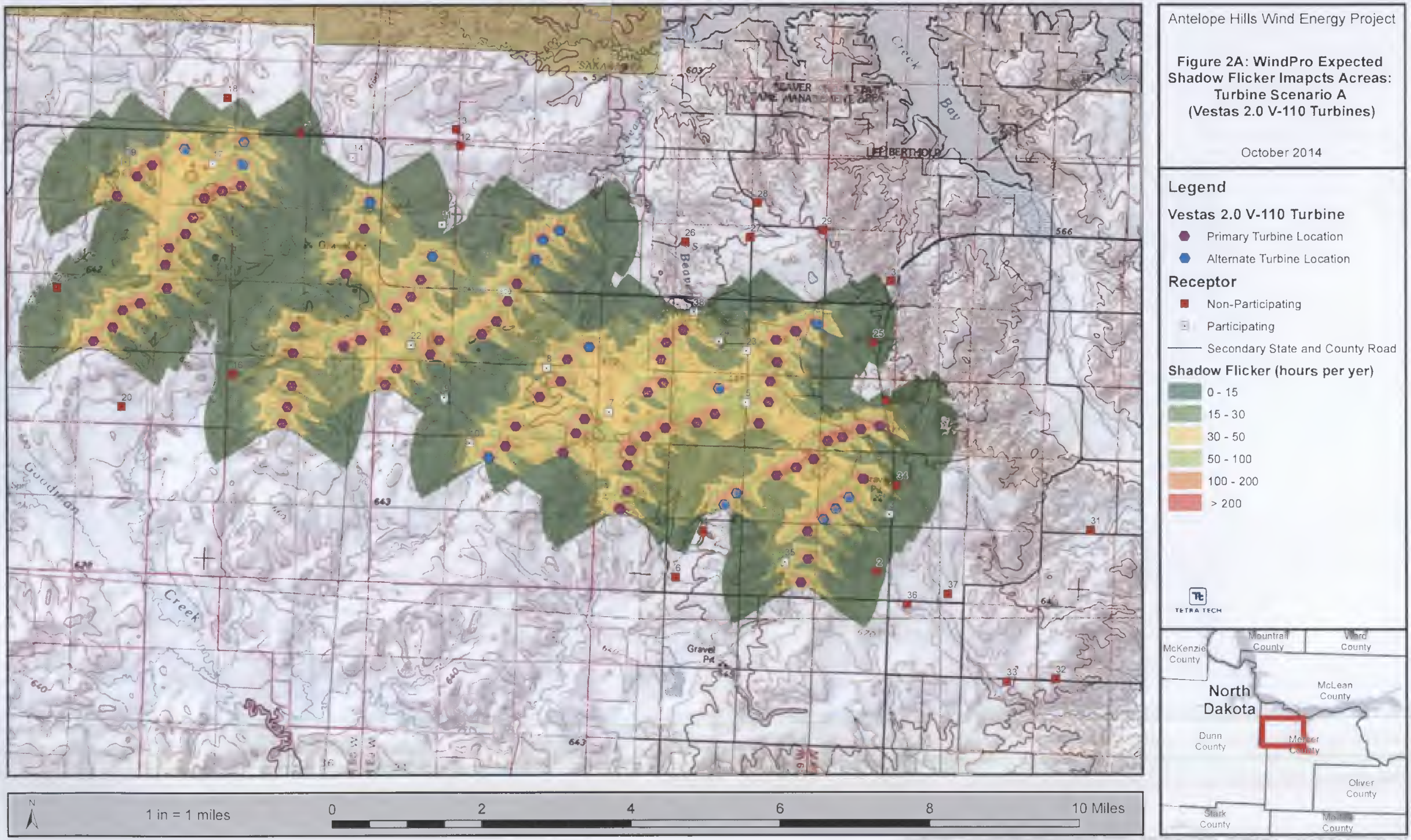

Antelope Hills Wind Energy Project

Figure 2A: WindPro Expected Shadow Flicker Imapcts Acreas: Turbine Scenario A (Vestas 2.0 V-110 Turbines)

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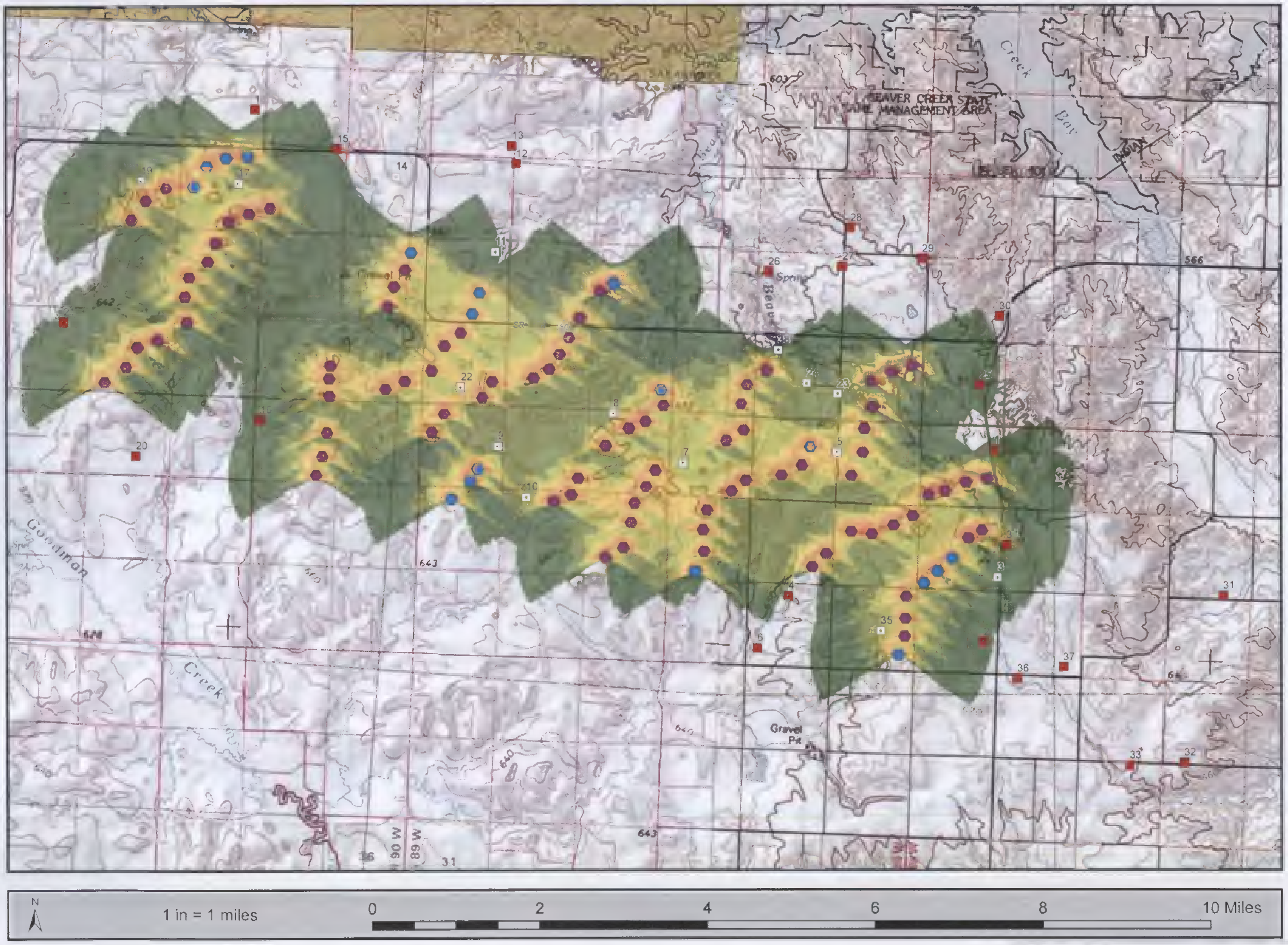
Antelope Hills Wind Energy Project

Figure 2B: WindPro Expected Shadow Flicker Imapcts Acreas: Turbine Scenario B (Vestas 2.0 V-100 Turbines)

October 2014



Legend

Vestas 2.0 V-100 Turbine

- Primary Turbine Location
- Alternate Turbine Location

Receptor

- Non-Participating
- Participating

Shadow Flicker (hours per yer)

- 0 - 15
- 15 - 30
- 30 - 50
- 50 - 100
- 100 - 200
- > 200
- Secondary State and County Road

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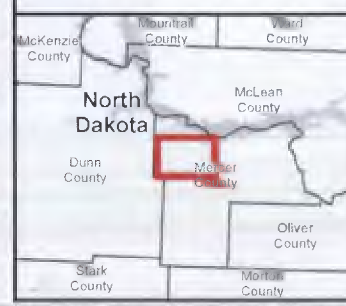

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ATTACHMENT A.

Detailed Summary of WindPro Shadow Flicker Analysis Results

Antelope Hills Wind Project
WindPro Shadow Flicker Analysis Results Summary
Turbine Scenario A (Vestas 2.0 V-110 Turbines)

Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Participation Status
1	278,806	5,254,954	9:45:00	
2	278,591	5,251,239	2:17:00	
3	278,865	5,252,493	11:26:00	Signed
4	274,851	5,252,134	0:00:00	
5	275,780	5,254,924	63:14:00	Signed
6	274,254	5,251,124	0:00:00	
7	272,833	5,254,718	40:35:00	Signed
8	271,493	5,255,678	66:13:00	Signed
9	269,279	5,255,041	12:53:00	Signed
10	269,821	5,254,052	42:50:00	Signed
11	269,241	5,258,813	2:01:00	Signed
12	269,646	5,260,514	0:00:00	
13	269,567	5,260,873	0:00:00	
14	267,336	5,260,278	0:00:00	Signed
15	266,202	5,260,810	3:01:00	
16	264,706	5,255,559	13:03:00	
17	264,288	5,260,144	44:42:00	Signed
18	264,616	5,261,580	0:00:00	
19	262,398	5,260,201	50:01:00	Signed
20	262,293	5,254,866	0:00:00	
21	260,903	5,257,460	4:05:00	
22	268,565	5,256,188	54:59:00	Signed
23	275,798	5,256,049	42:07:00	Signed
24	275,210	5,256,258	25:13:00	Signed
25	278,530	5,256,220	0:00:00	
26	274,486	5,258,418	0:00:00	
27	275,895	5,258,521	0:00:00	
28	276,052	5,259,267	0:00:00	
29	277,426	5,258,672	0:00:00	
30	278,912	5,257,558	0:00:00	
31	283,193	5,252,142	0:00:00	
32	282,431	5,248,908	0:00:00	
33	281,382	5,248,849	0:00:00	
34	279,035	5,253,117	10:12:00	
35	276,616	5,251,460	33:54:00	Signed
36	279,237	5,250,527	0:00:00	
37	280,120	5,250,752	0:00:00	
38	274,669	5,256,903	27:25:00	Signed

Antelope Hills Project
WindPro Shadow Flicker Analysis Results Summary
Turbine Scenario B (Vestas 2.0 V-100 Turbines)

Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Participation Status
1	278,806	5,254,954	8:23:00	
2	278,591	5,251,239	2:59:00	
3	278,865	5,252,493	9:43:00	Signed
4	274,851	5,252,134	0:00:00	
5	275,780	5,254,924	51:40:00	Signed
6	274,254	5,251,124	0:00:00	
7	272,833	5,254,718	35:39:00	Signed
8	271,493	5,255,678	48:05:00	Signed
9	269,279	5,255,041	22:40:00	Signed
10	269,821	5,254,052	36:56:00	Signed
11	269,241	5,258,813	0:48:00	Signed
12	269,646	5,260,514	0:00:00	
13	269,567	5,260,873	0:00:00	
14	267,336	5,260,278	0:00:00	Signed
15	266,202	5,260,810	0:00:00	
16	264,706	5,255,559	10:57:00	
17	264,288	5,260,144	31:20:00	Signed
18	264,616	5,261,580	0:00:00	
19	262,398	5,260,201	29:06:00	Signed
20	262,293	5,254,866	0:00:00	
21	260,903	5,257,460	3:32:00	
22	268,565	5,256,188	46:25:00	Signed
23	275,798	5,256,049	29:32:00	Signed
24	275,210	5,256,258	21:54:00	Signed
25	278,530	5,256,220	0:00:00	
26	274,486	5,258,418	0:00:00	
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30	278,912	5,257,558	0:00:00	
31	283,193	5,252,142	0:00:00	
32	282,431	5,248,908	0:00:00	
33	281,382	5,248,849	0:00:00	
34	279,035	5,253,117	25:16:00	
35	276,616	5,251,460	38:57:00	Signed
36	279,237	5,250,527	0:00:00	
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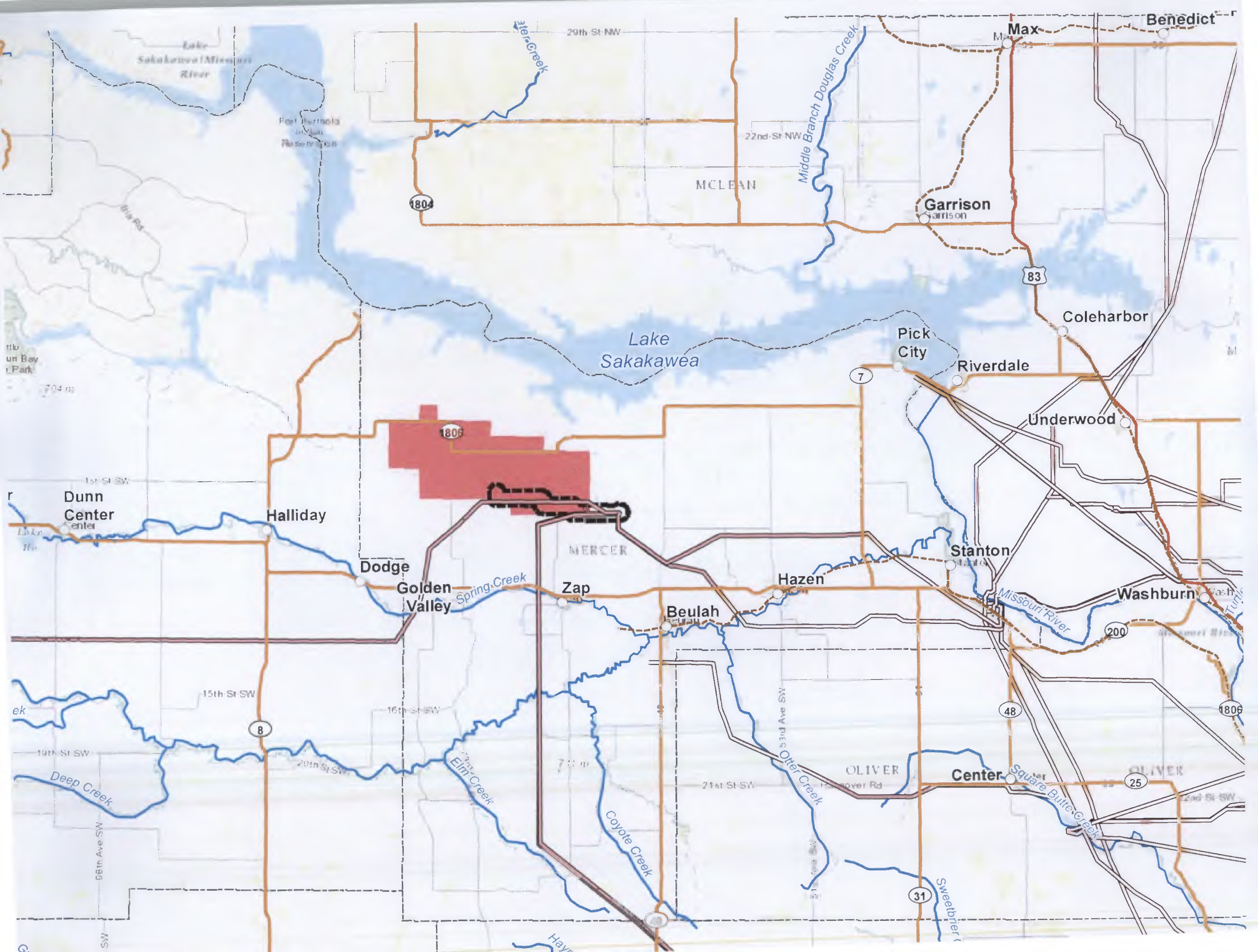
38	274,669	5,256,903	13:15:00	Signed



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Dunn Center
Halliday
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Golden Valley
Spring Creek
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MERCER
Hazen
Stanton
Beulah
Washburn
Missouri River
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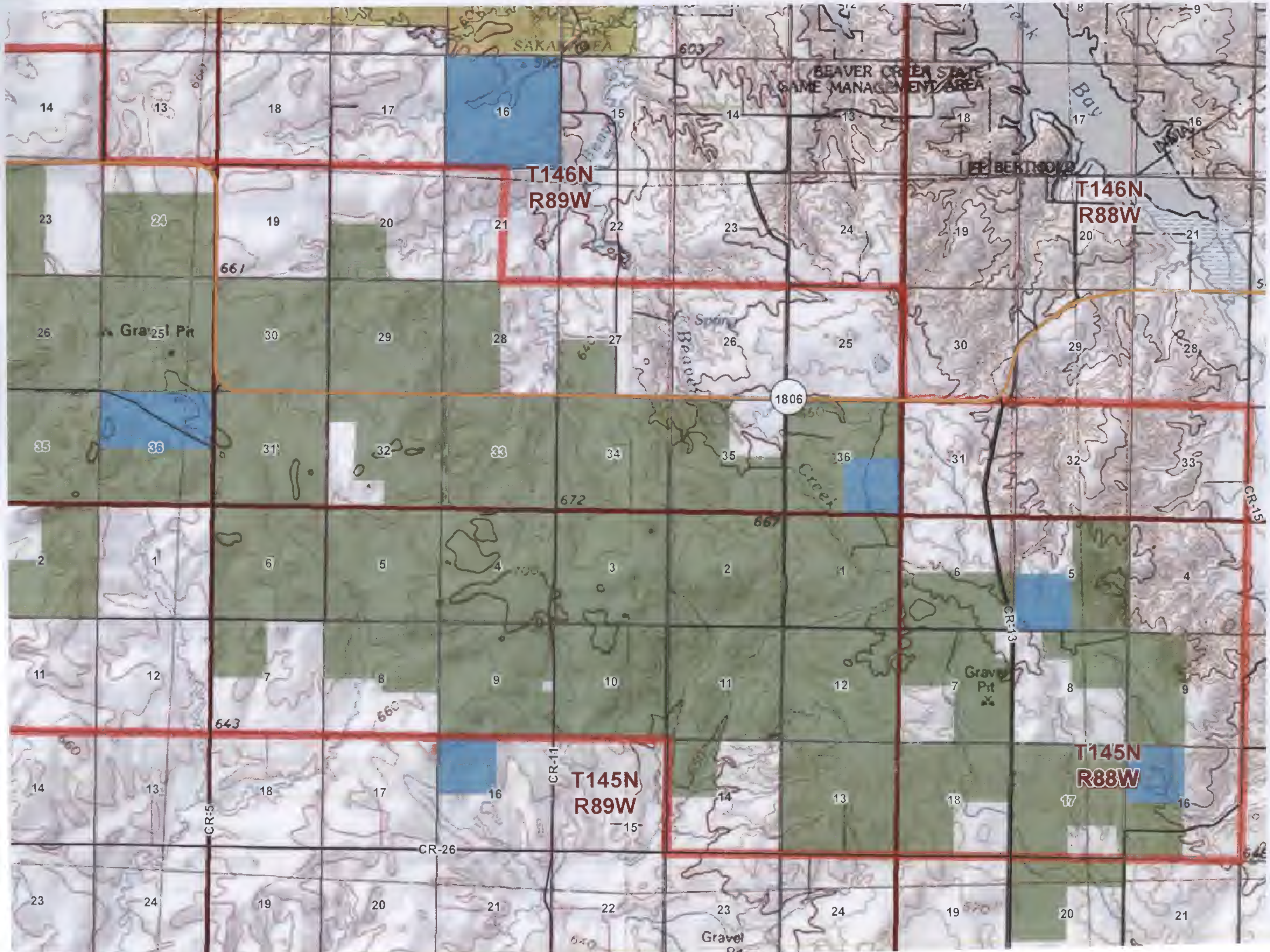
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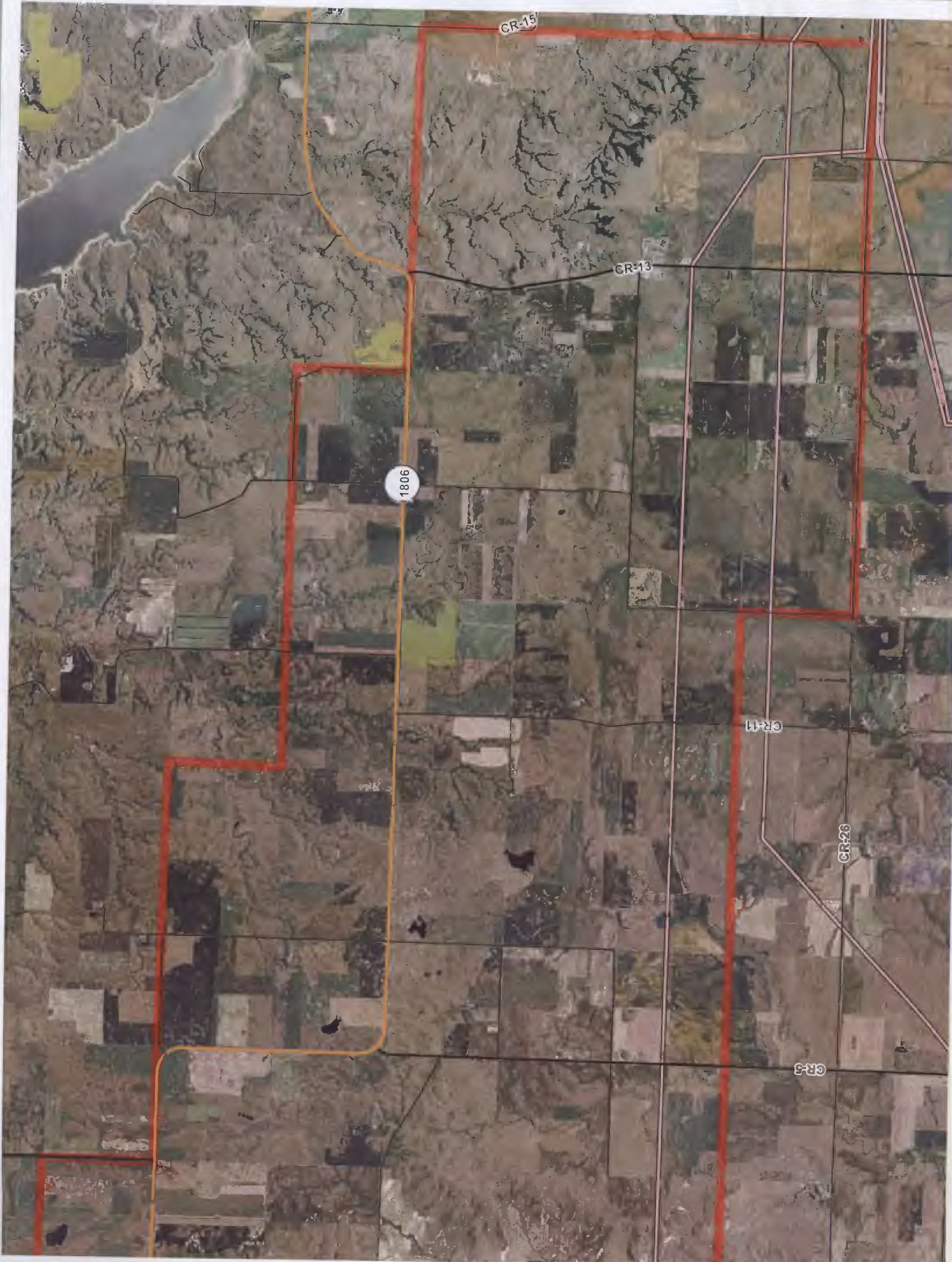

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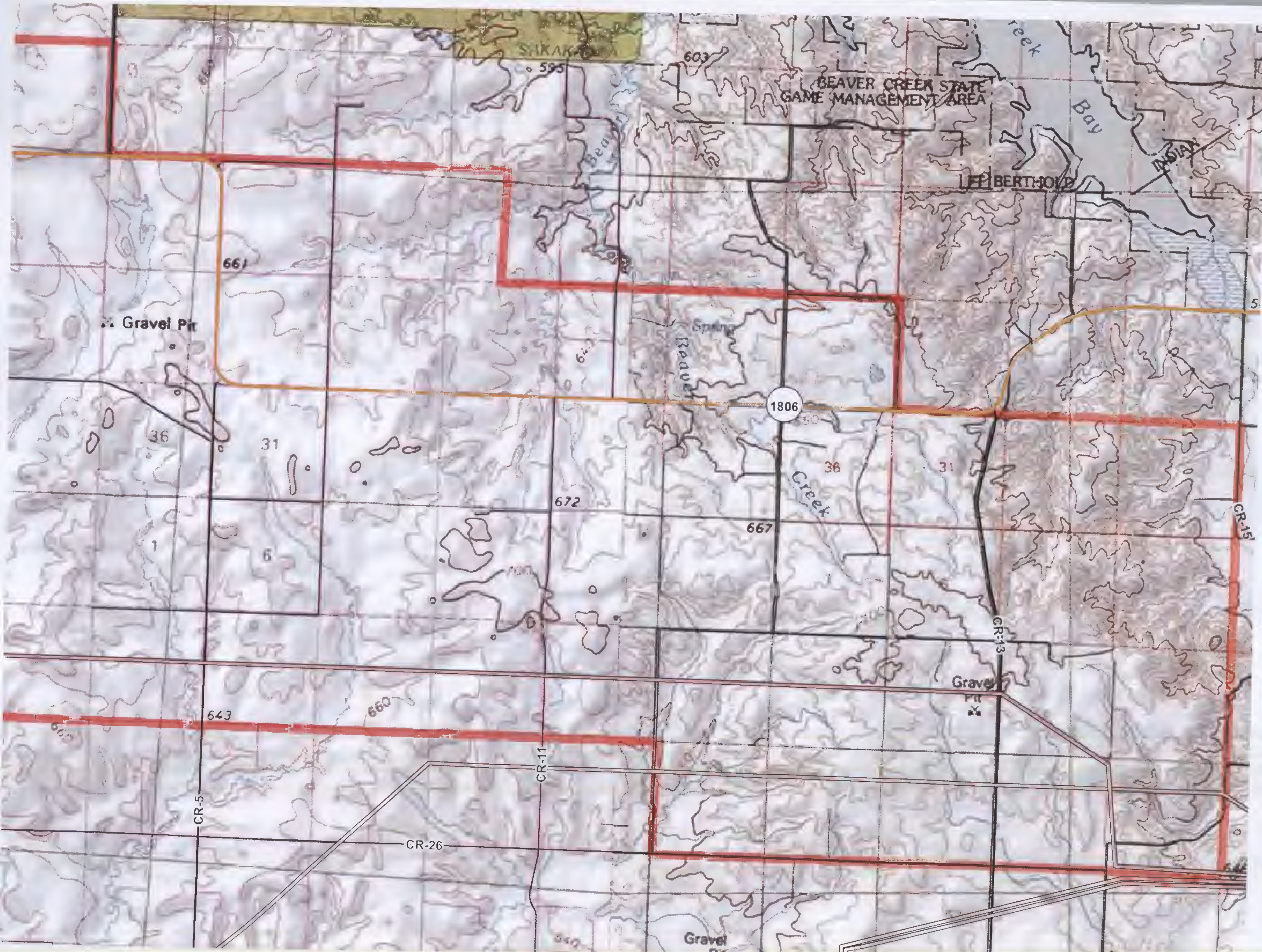
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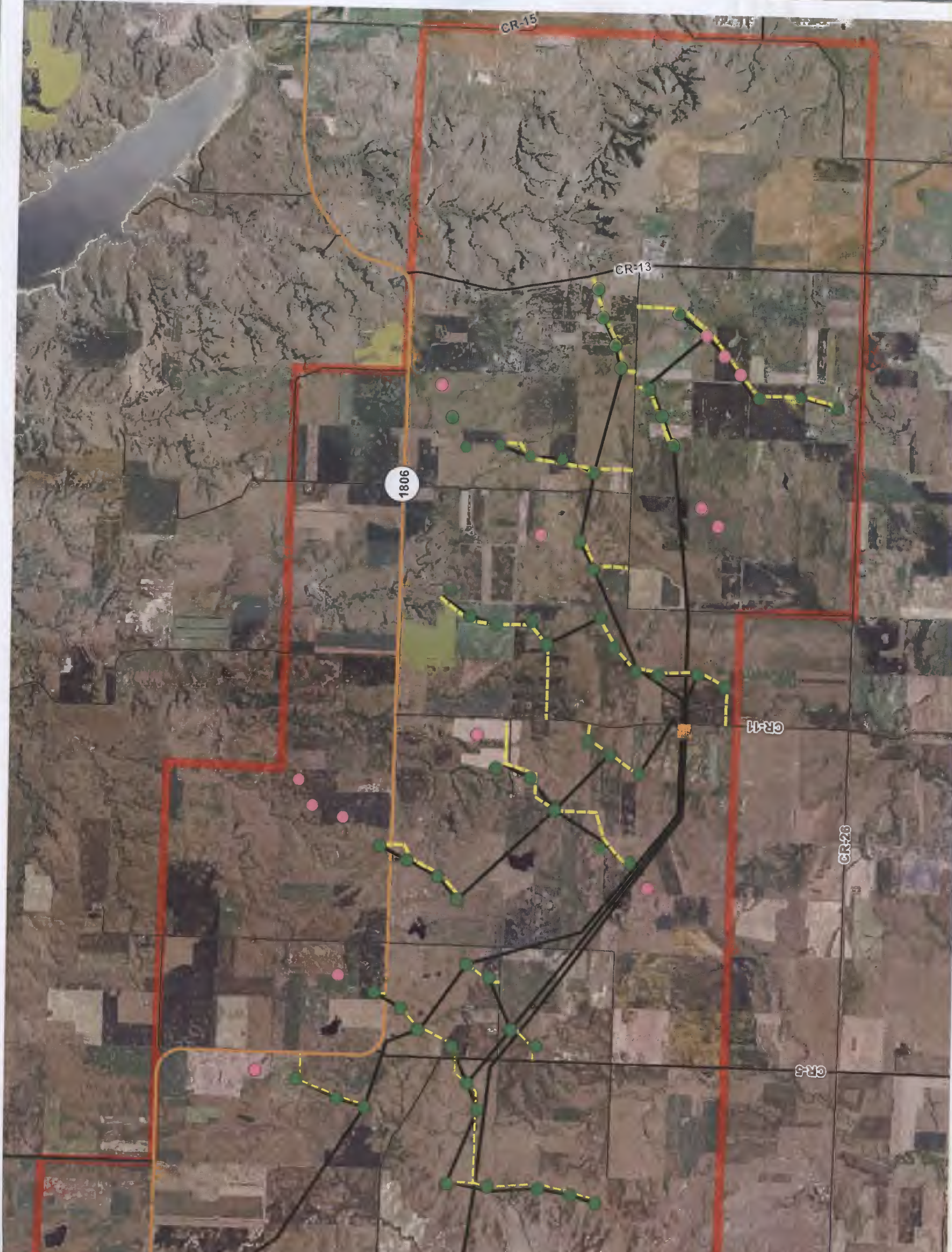
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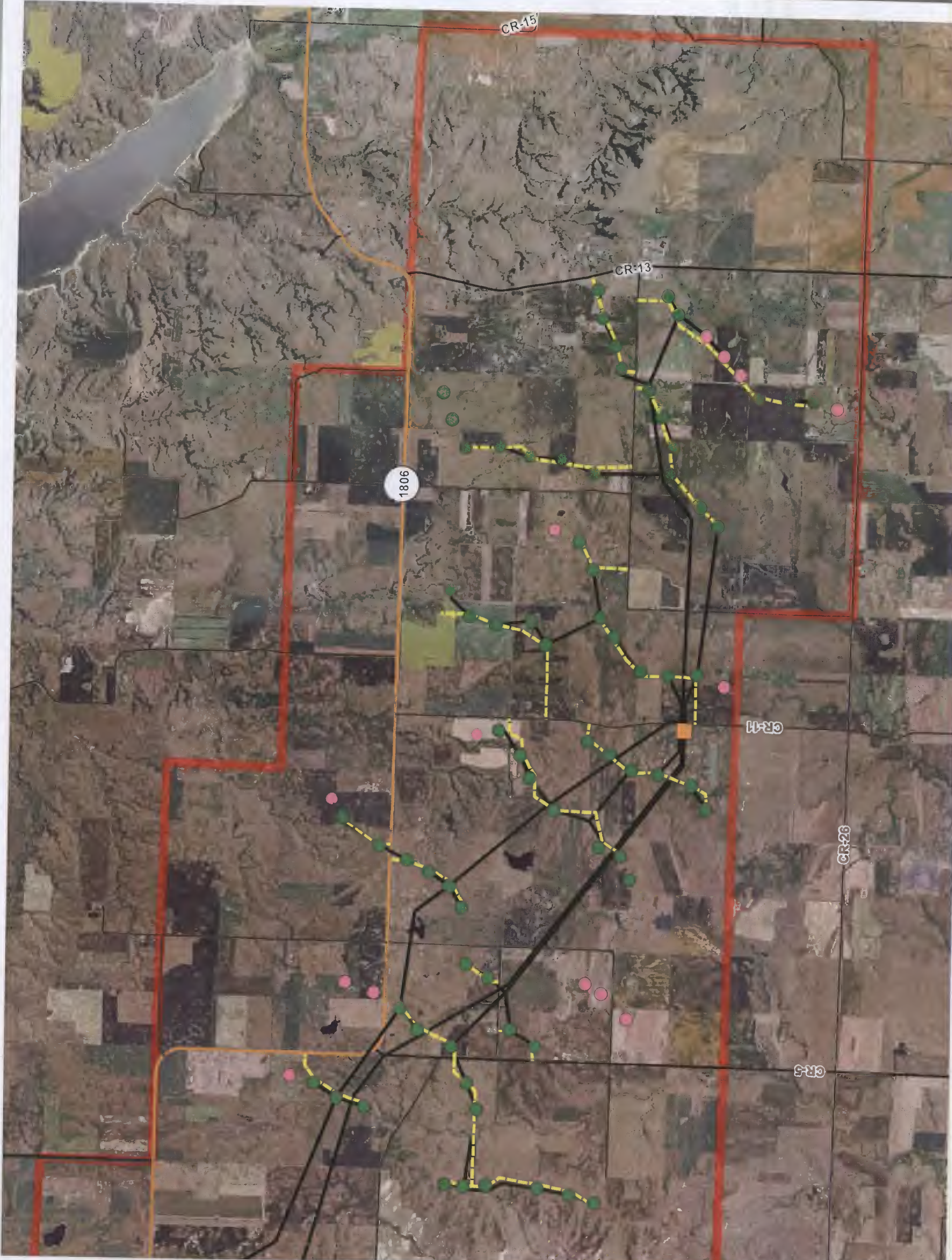

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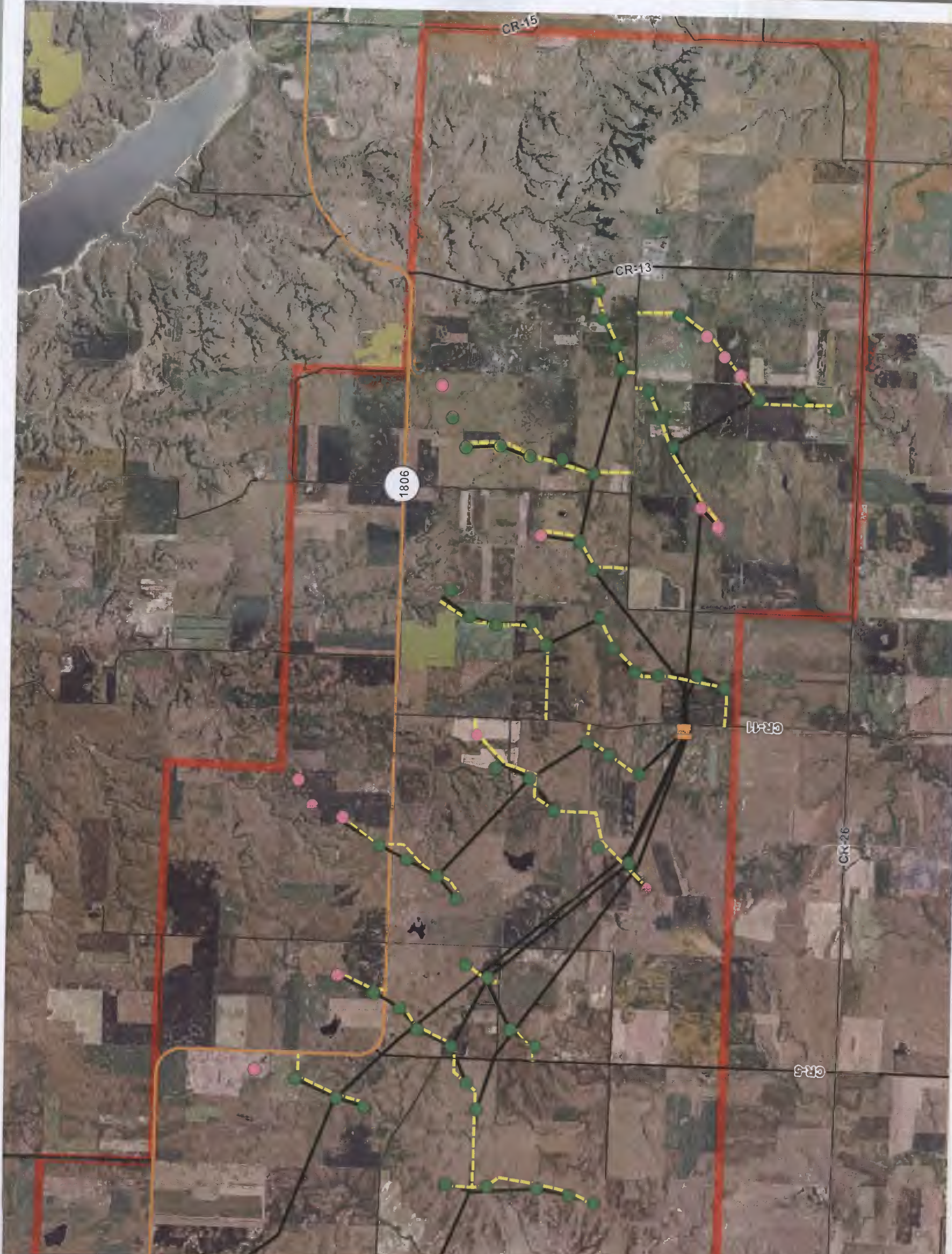

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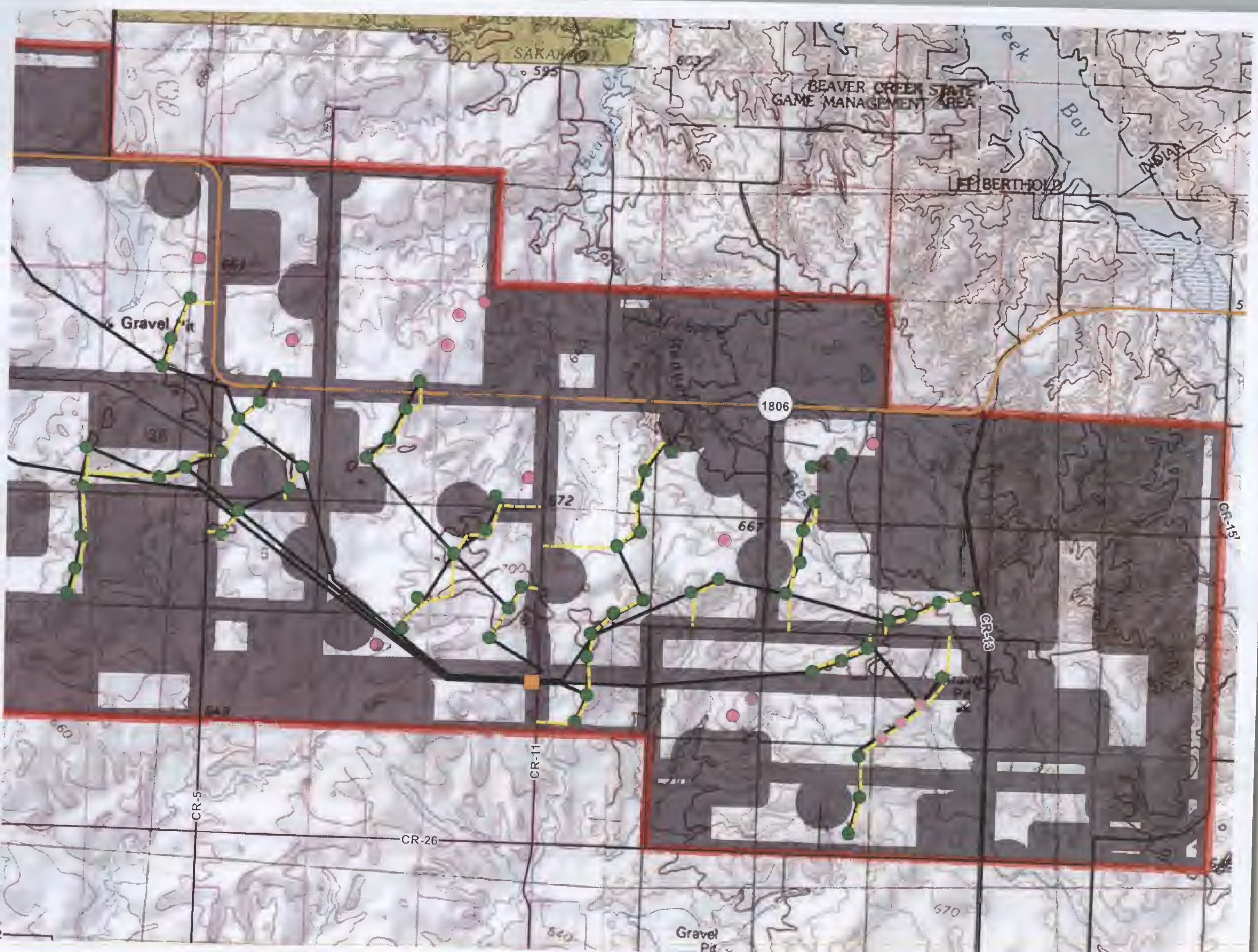

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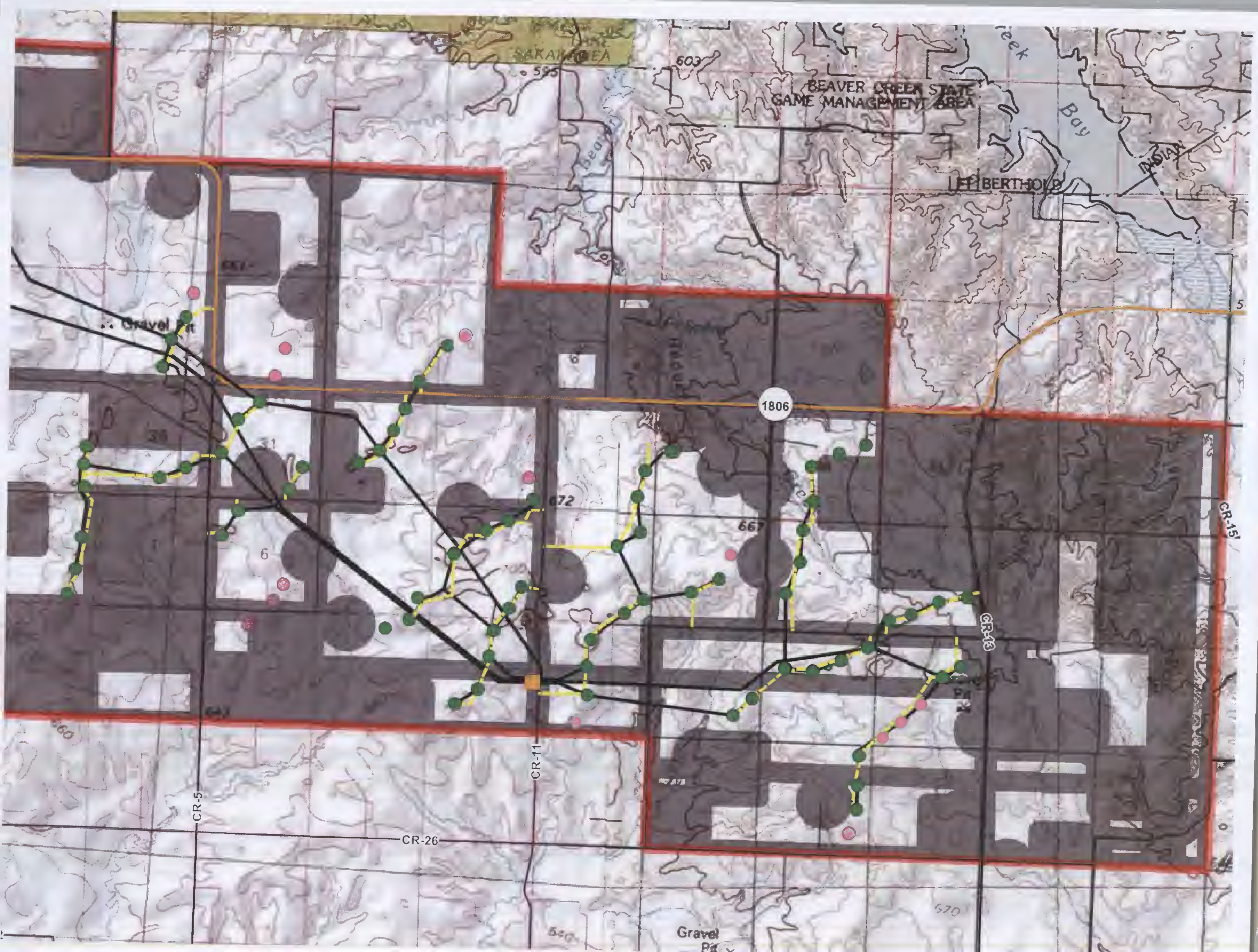
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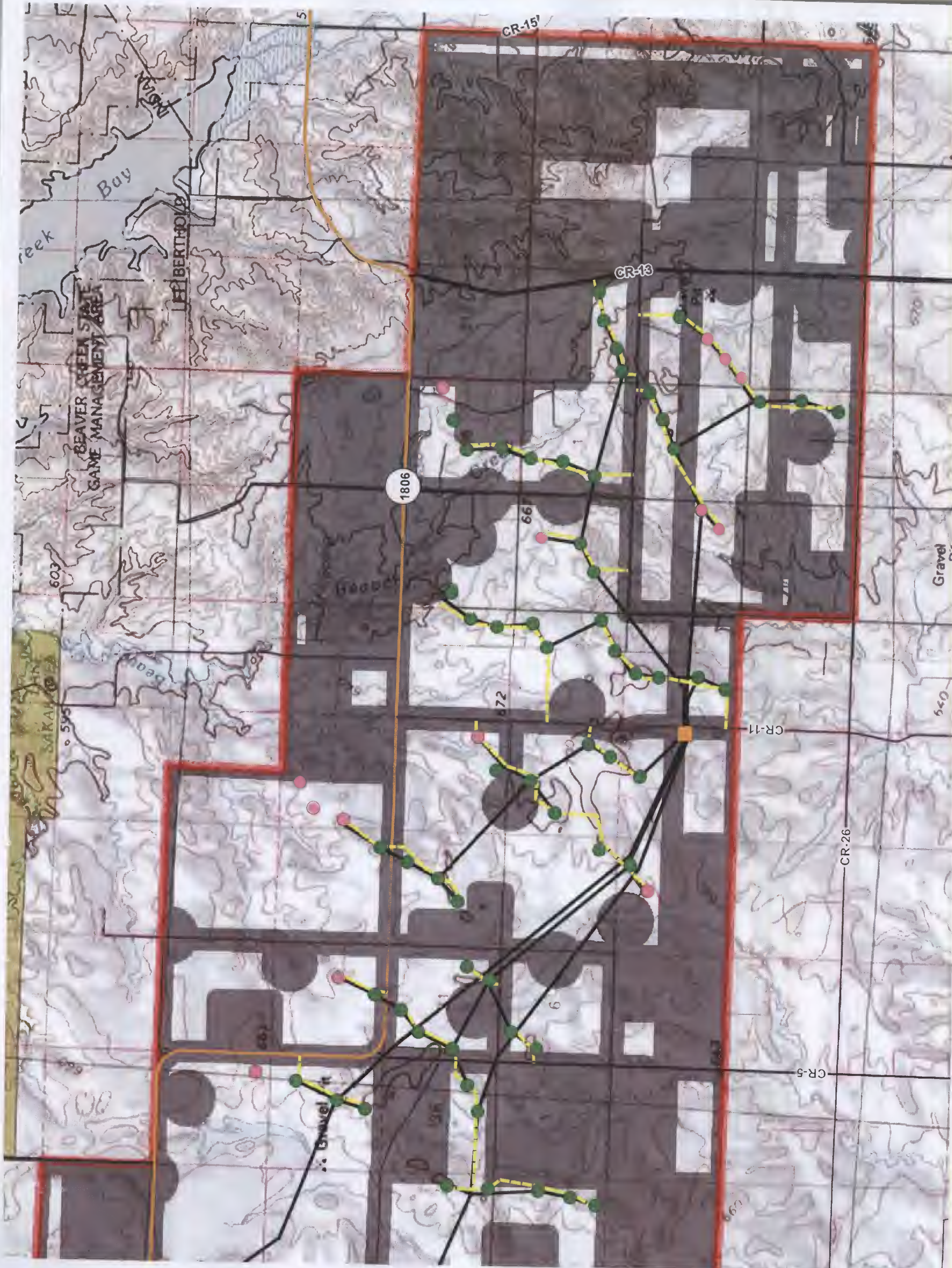

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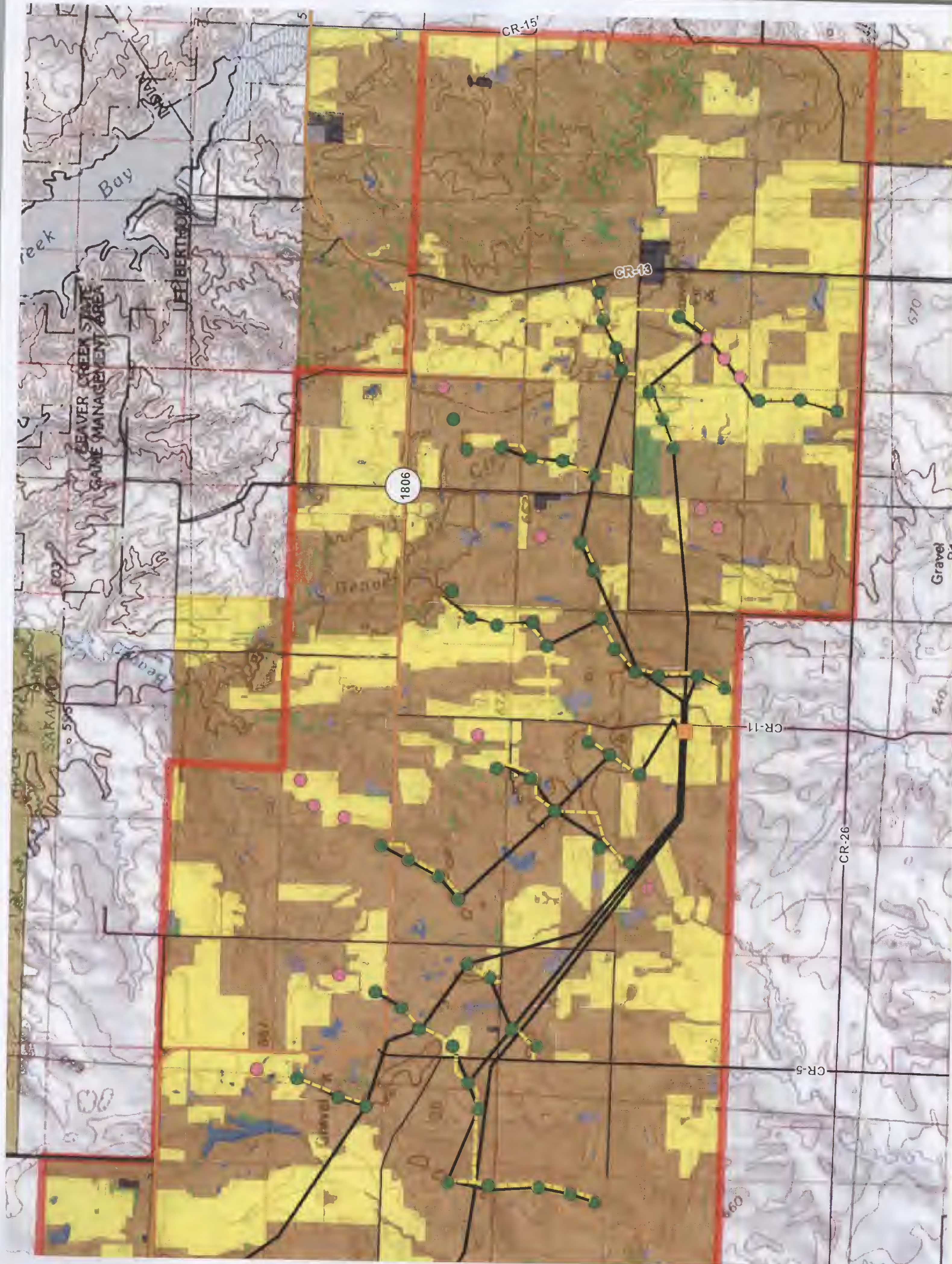
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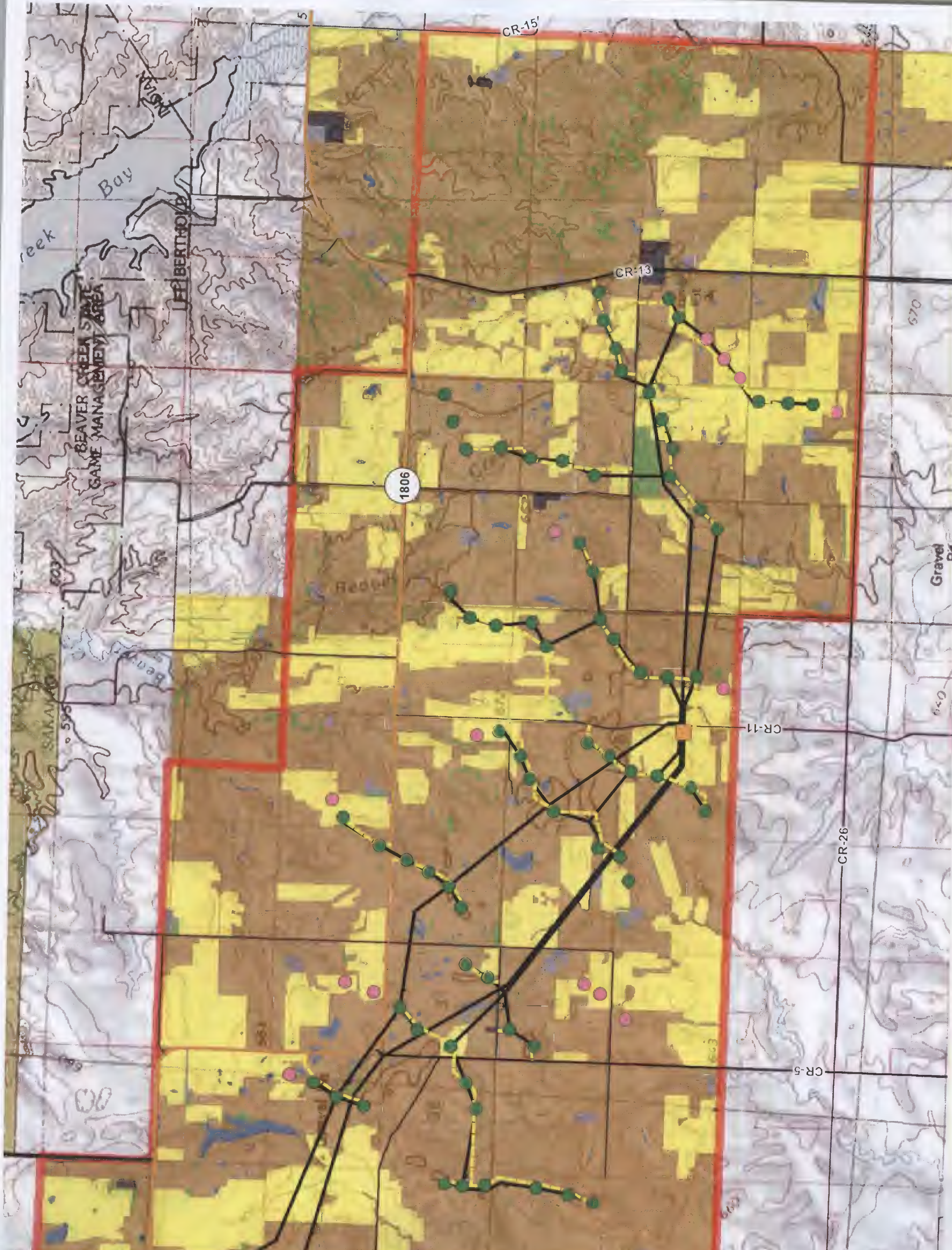
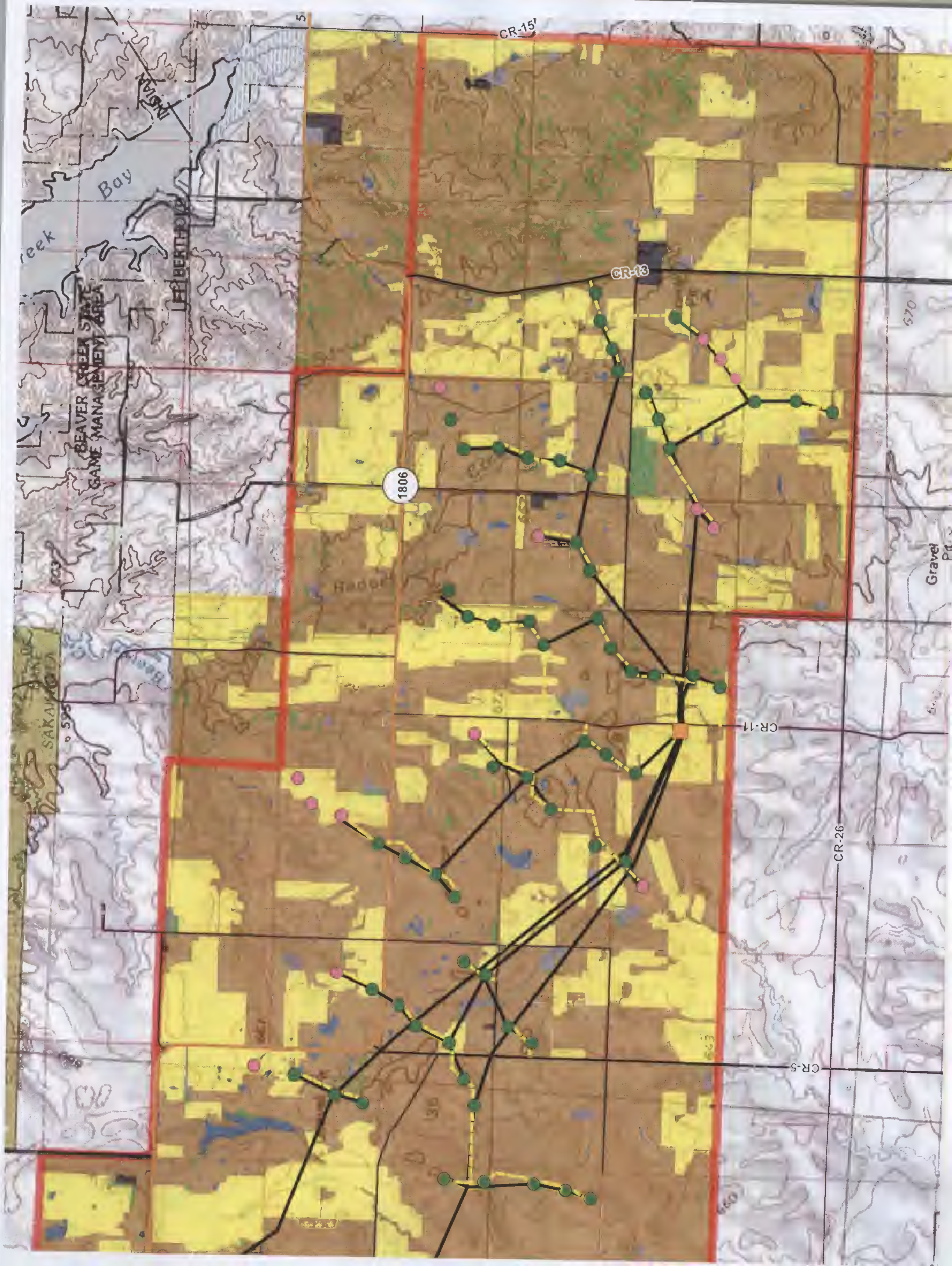
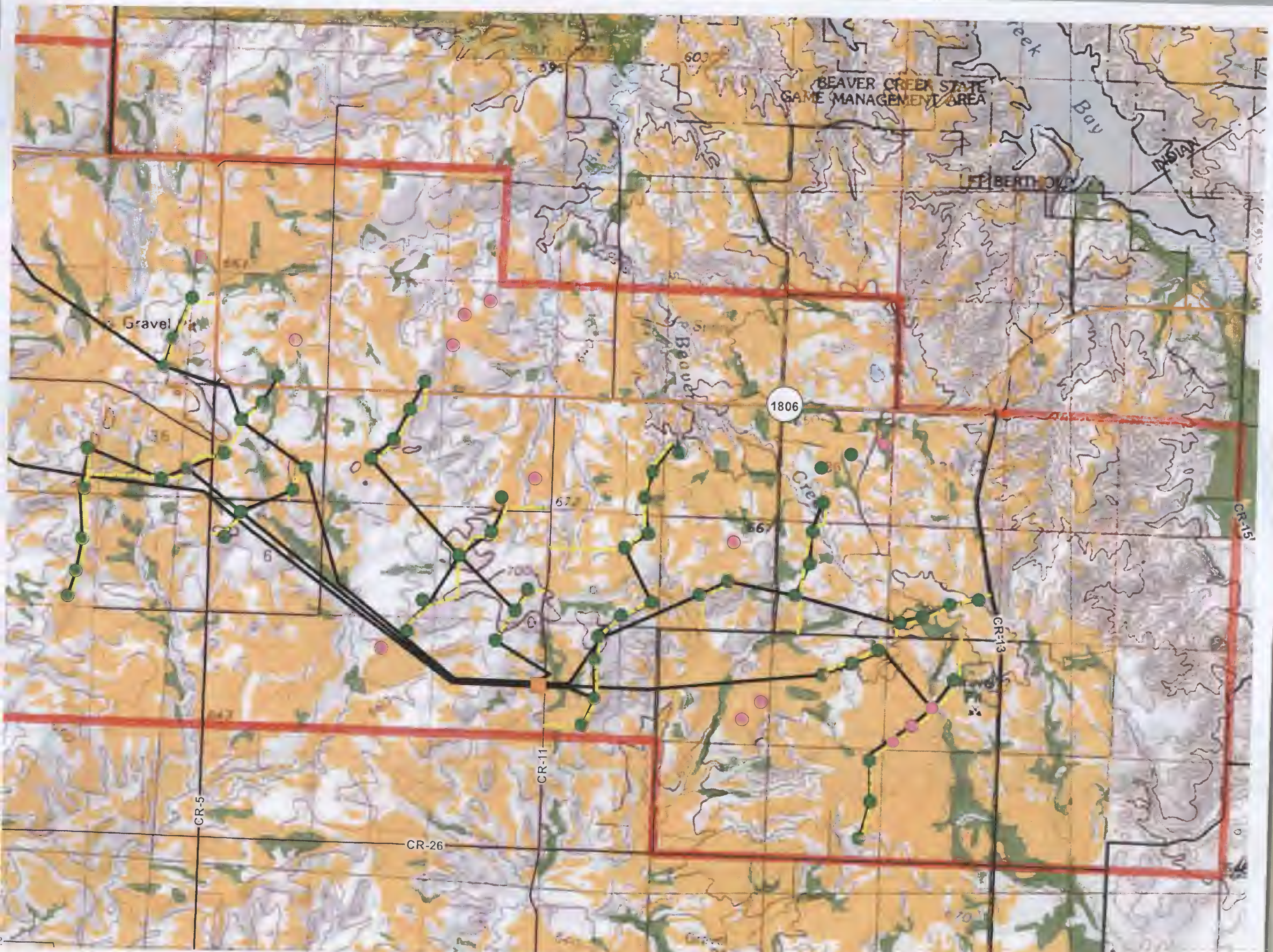
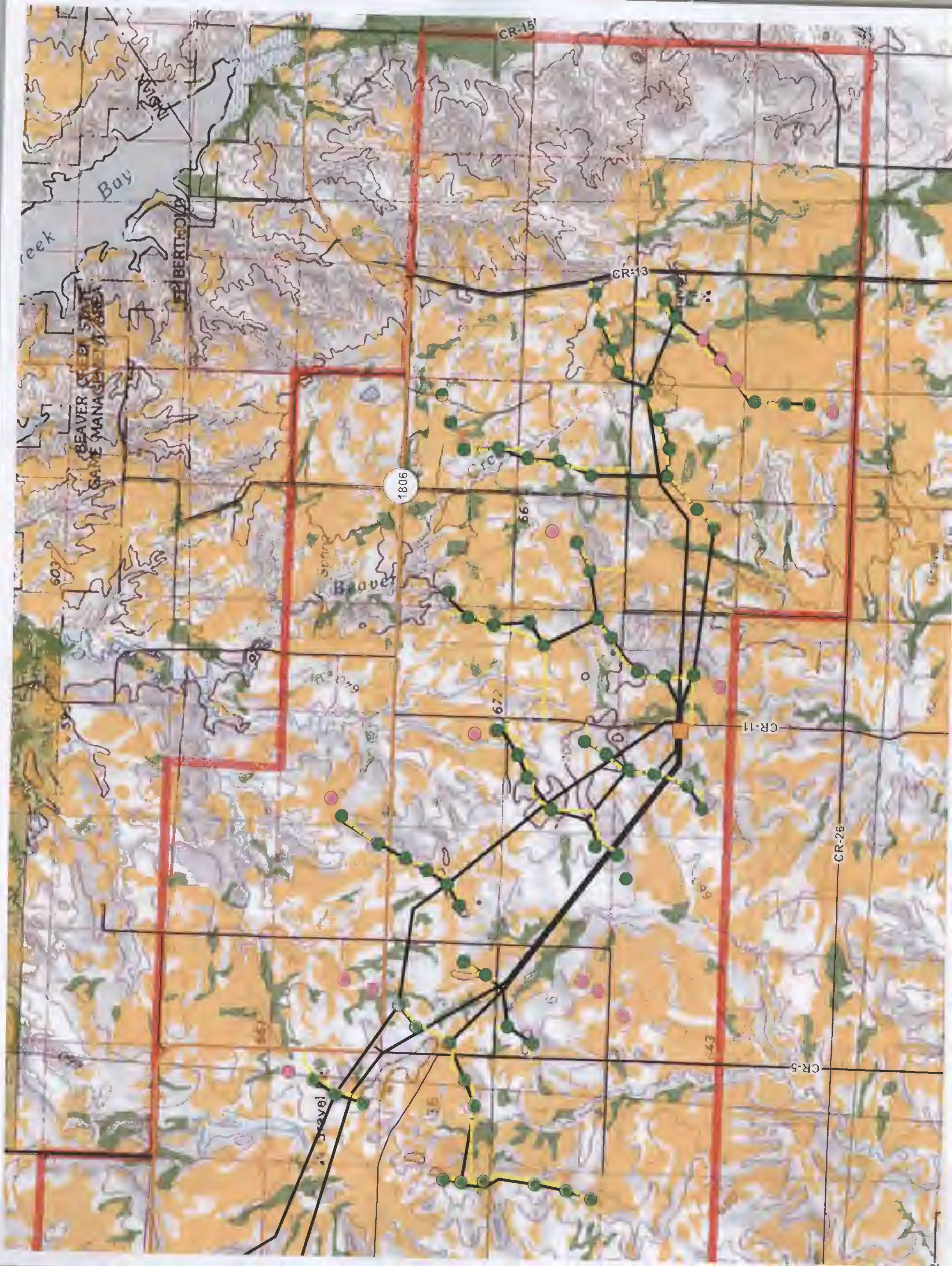
Bay
Gravel Pit


CR-15'
CR-13
1806
CR-11
CR-5
CR-26
Bay
BEAVER CREEK STATE
GAME MANAGEMENT AREA
Gravel
670

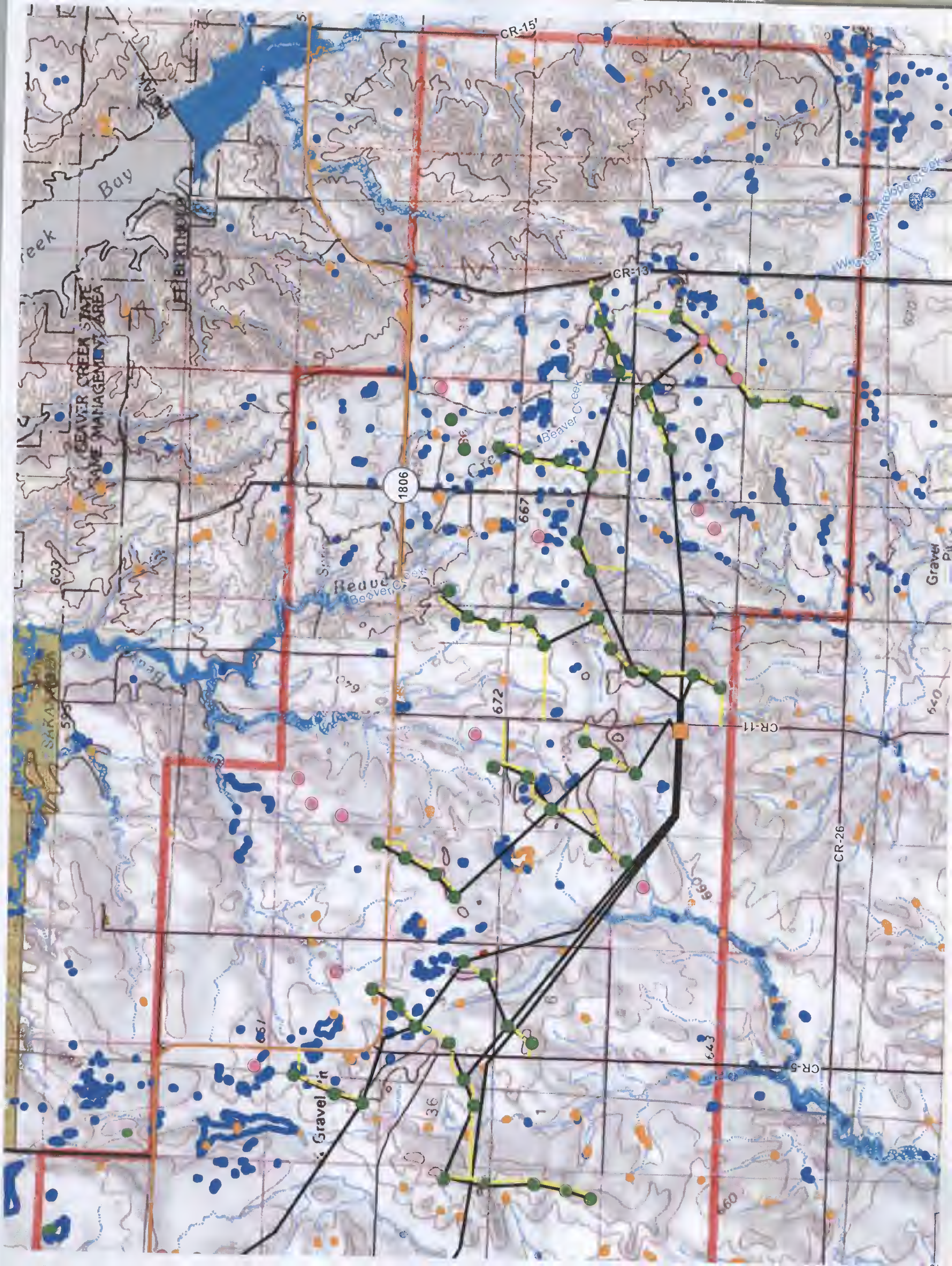

CR-15
CR-13
1806
CR-11
CR-5
CR-26
Bay
BEAVER CREEK STATE GAME MANAGEMENT AREA
Gravel


BEAVER CREEK STATE
GAME MANAGEMENT AREA
Bay
FT. BERTHOLD
INDIAN
1806
Beaver
Cree
Gravel Pit
CR-5
CR-11
CR-13
CR-15
CR-26
36
6
672
667
700
603
595

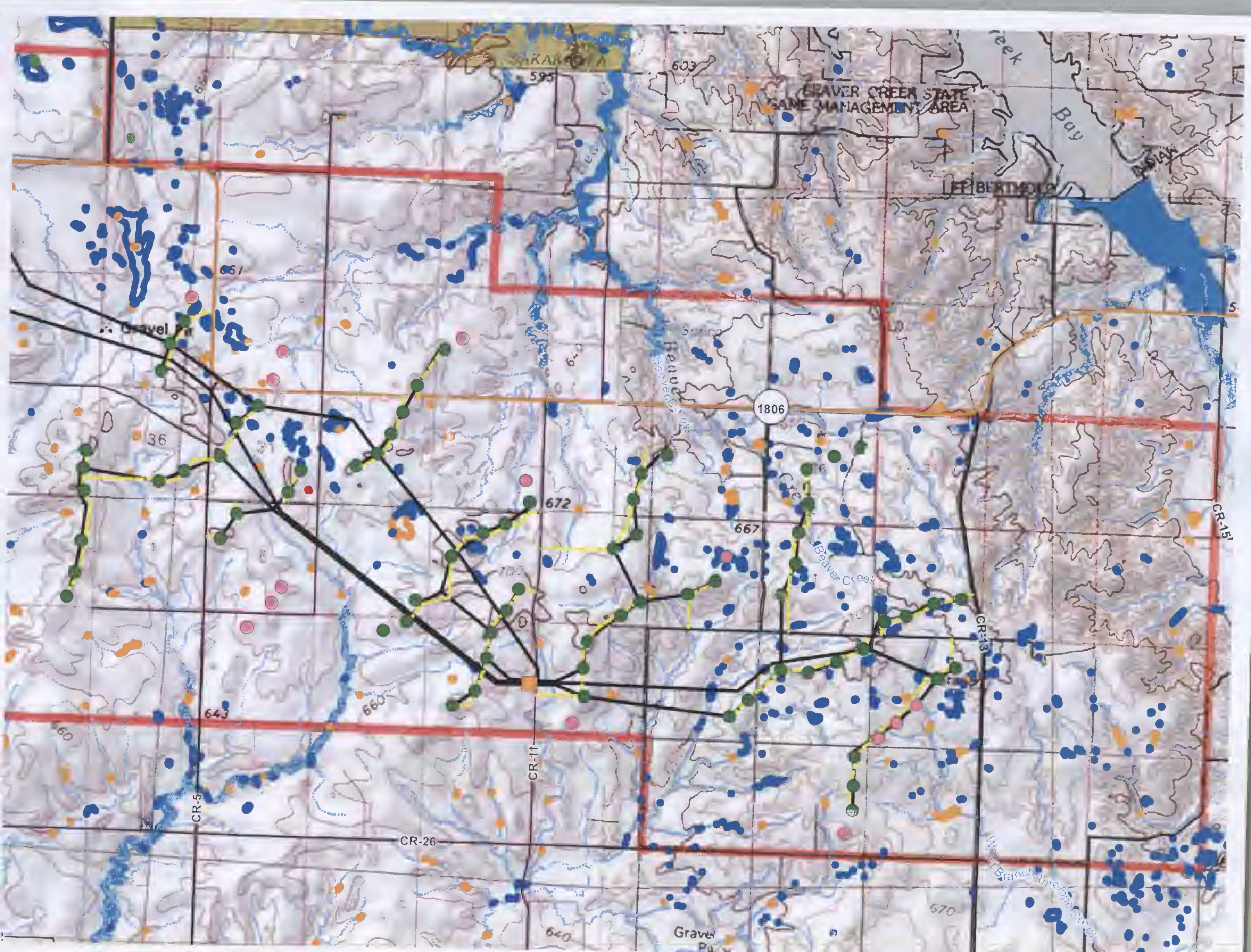


CR-15
CR-13
Bay
BEAVER CREEK STATE GAME MANAGEMENT AREA
1806
Beaver
CR-11
CR-26
CR-5
Gravel

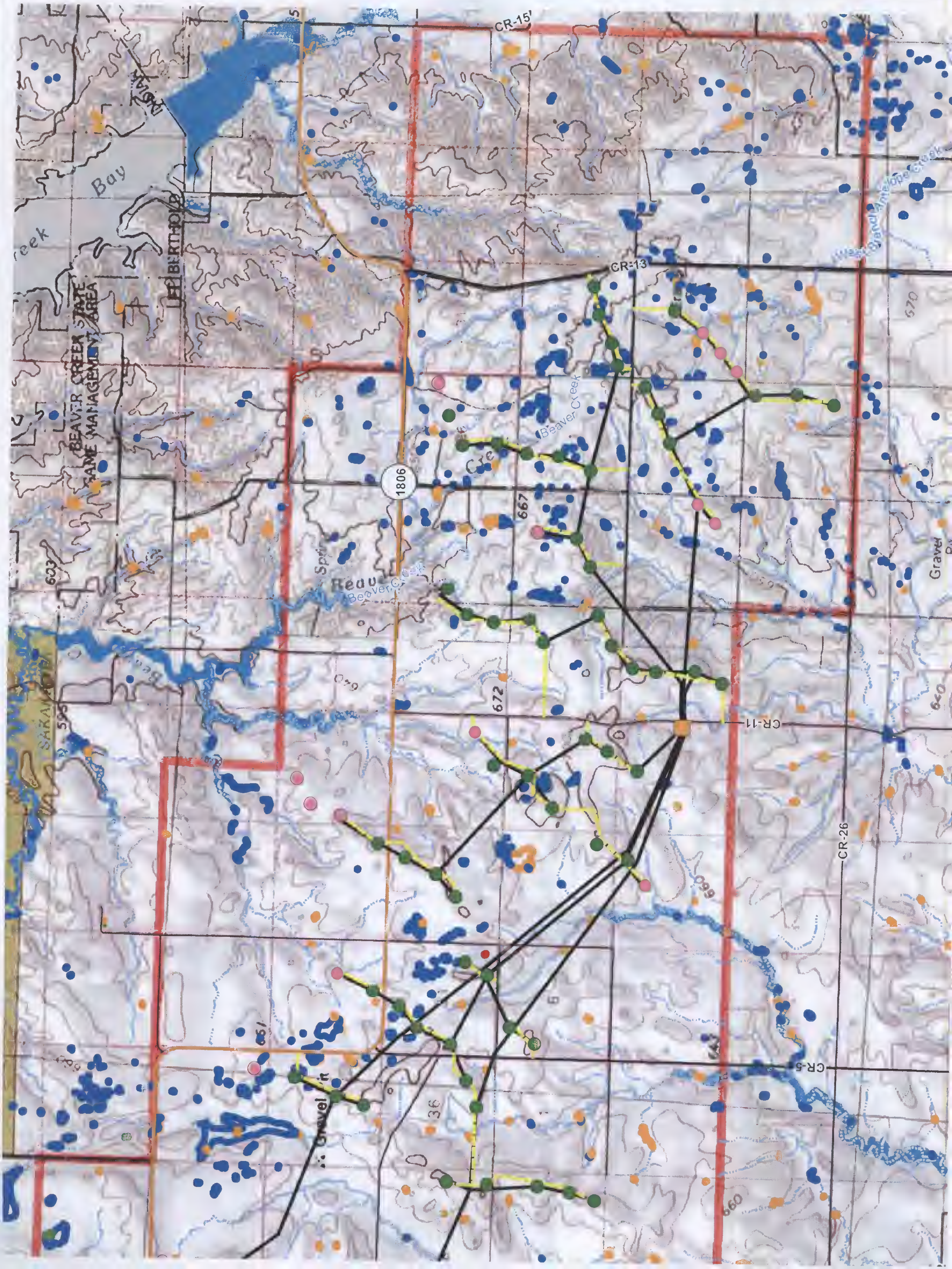

CR-15
CR-13
CR-11
CR-5
CR-26
1806
Bay
Creek
BEAVER CREEK STATE GAME MANAGEMENT AREA
FT BERTHOLD
Beaver
Gravel



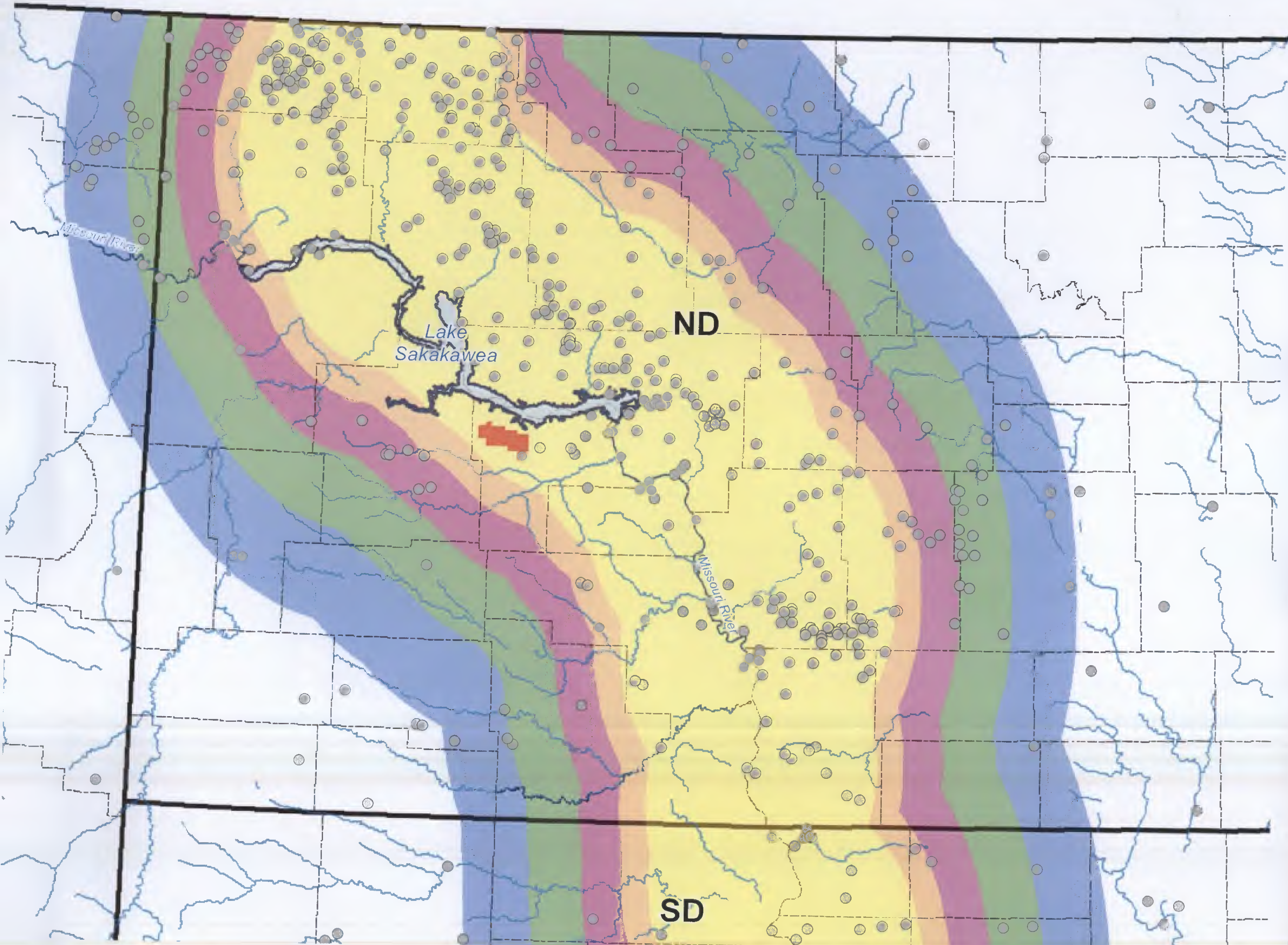
CR-15
CR-13
CR-11
CR-5
CR-26
1806
Beaver Creek
Beaver Cr
Bay
BEAVER CREEK STATE GAME MANAGEMENT AREA
Gravel Pit
667
672
643
640
660
651
603



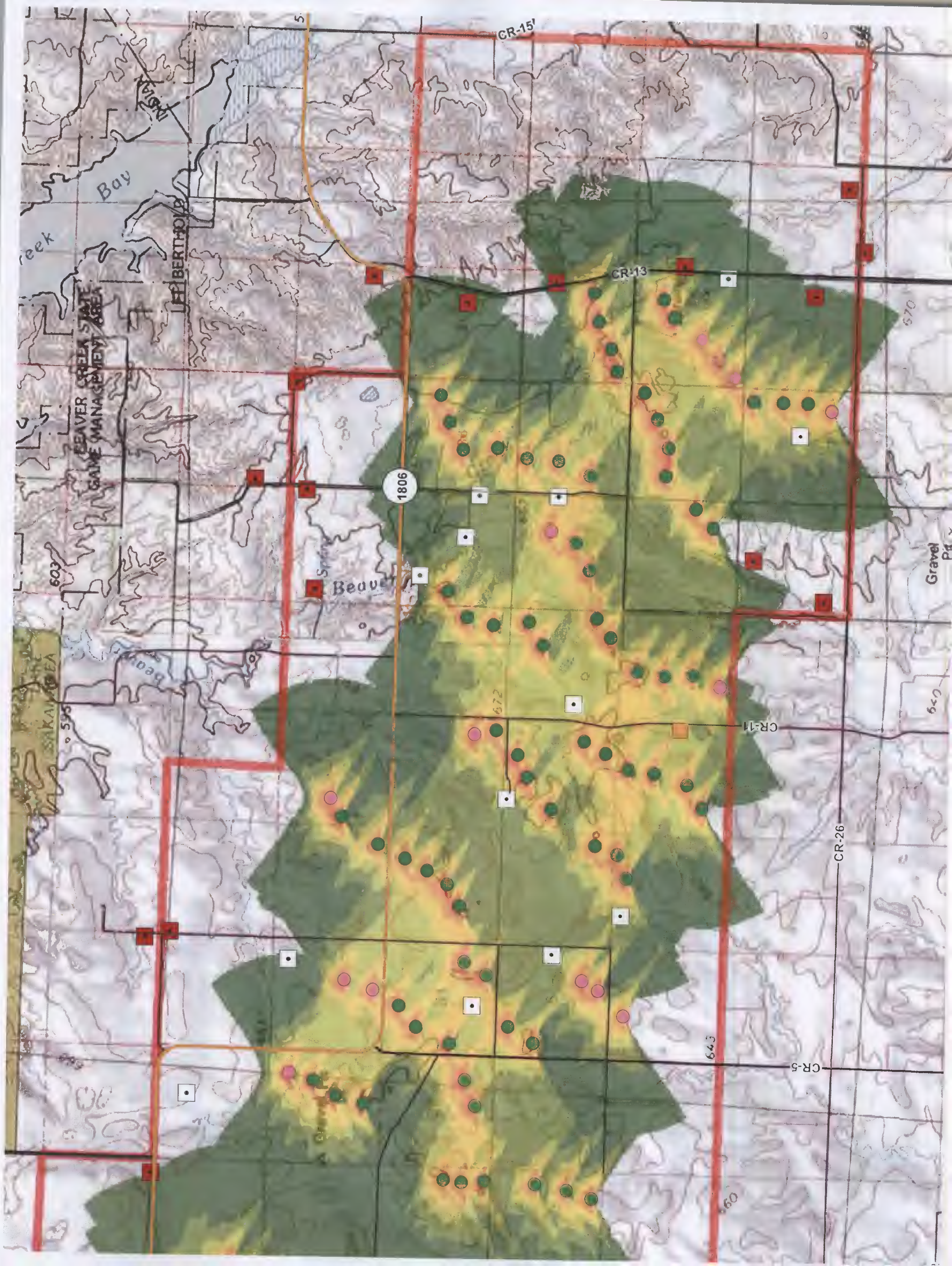
BEAVER CREEK STATE
GAME MANAGEMENT AREA
603
595
Bay
CR-15
CR-13
CR-11
CR-5
CR-26
1806
Beaver Creek
West Branch Antelope Creek
672
667
643
660
661
670
640
36
Gravel Pit

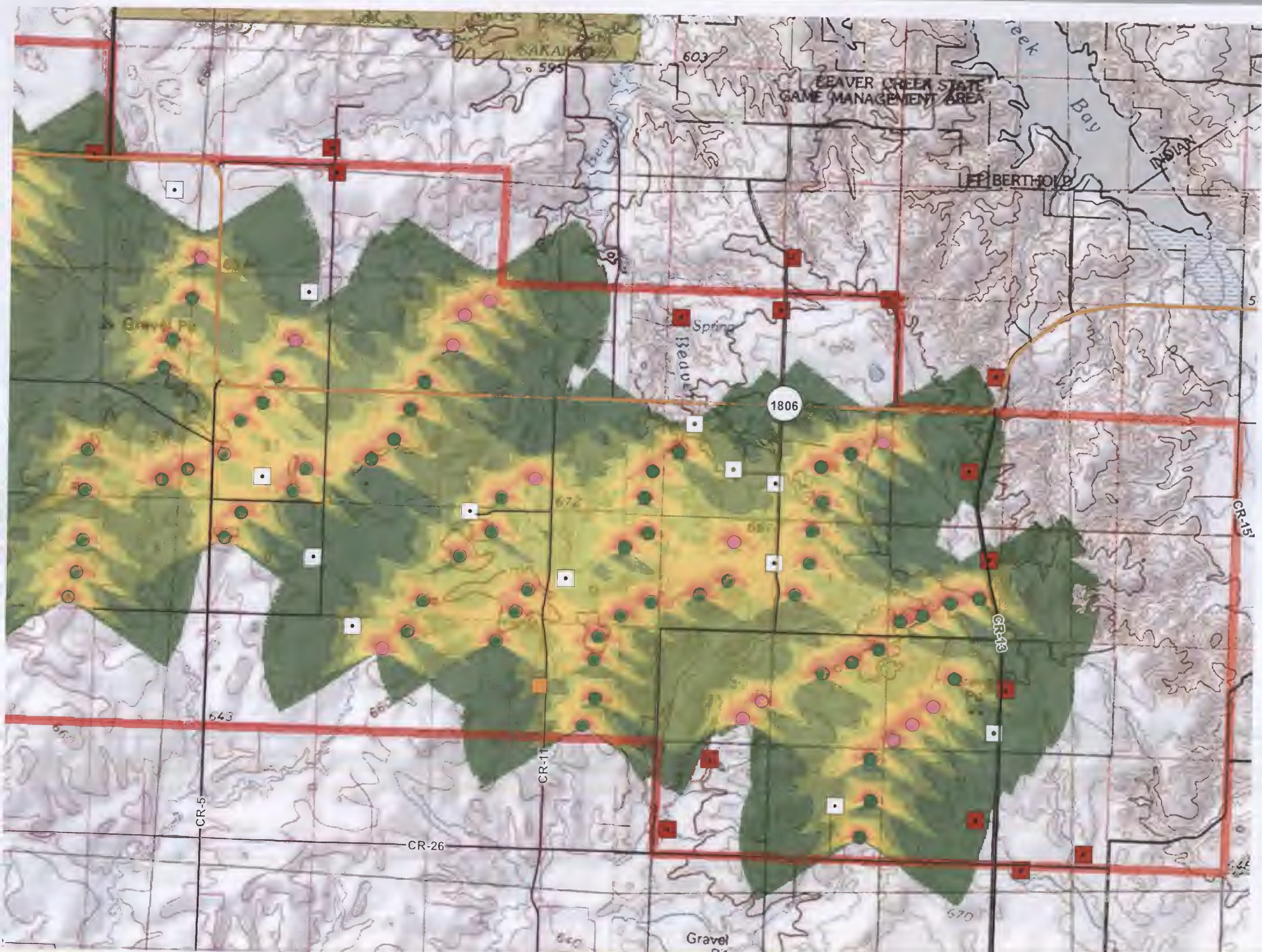


CR-15
CR-13
CR-11
CR-5
CR-26
1806
Beaver Creek
BEAVER CREEK STATE GAME MANAGEMENT AREA
Bay
667
672
640
660
603

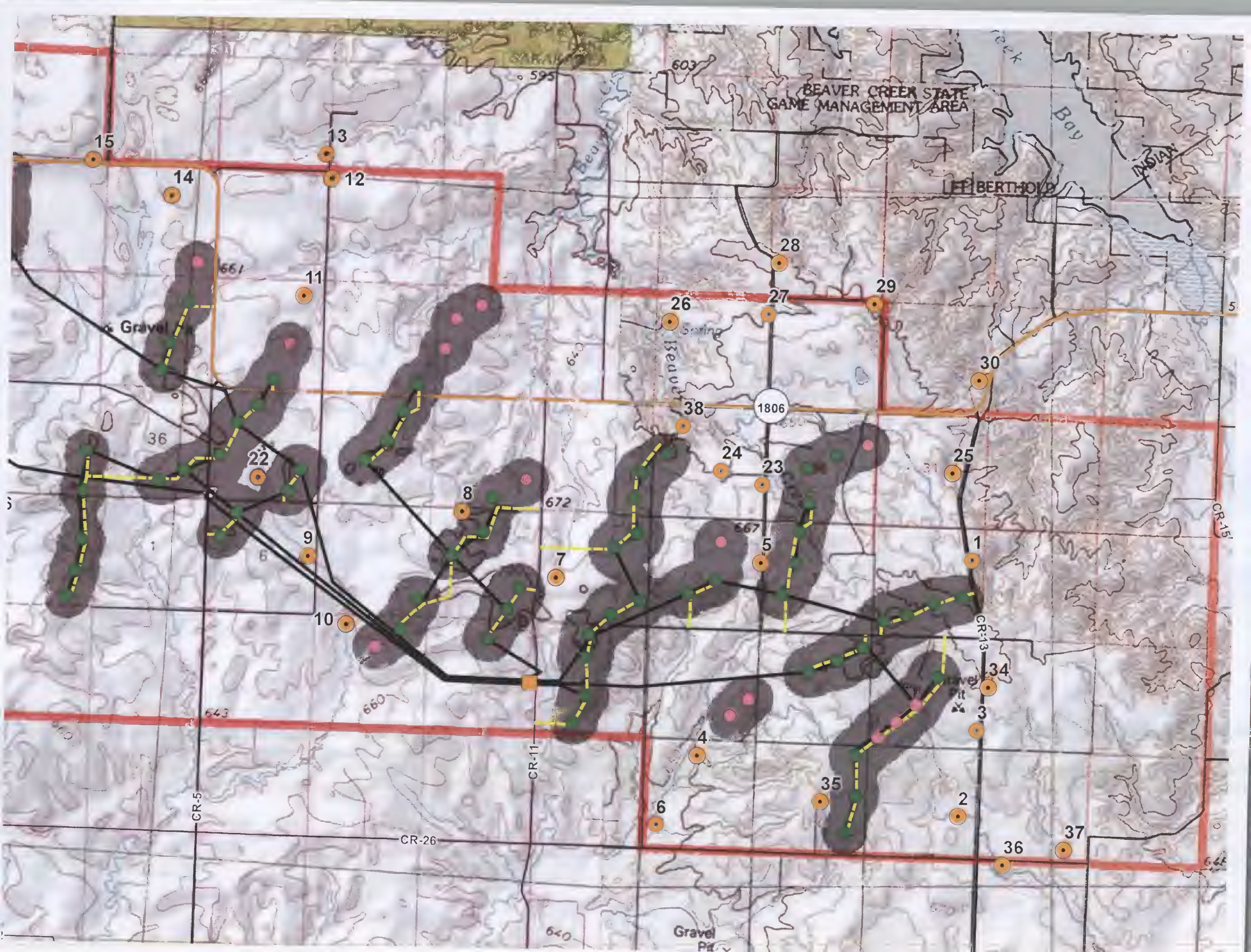


ND
SD
Lake Sakakawea
Missouri River
Missouri River


CR-15'
CR-13
1806
CR-11
CR-26
CR-5
Bay
BEAVER CREEK STATE
GAME MANAGEMENT AREA



BEAVER CREEK STATE GAME MANAGEMENT AREA
Bay
Spring
1806
CR-15'
CR-13
CR-11
CR-5
CR-26
643
603
595
Gravel



BEAVER CREEK STATE
GAME MANAGEMENT AREA
Bay
LEFT BERTHOLD
INDIAN
Gravel Pit
Gravel Pit
Gravel Pit
CR-5
CR-11
CR-26
CR-13
CR-15
1806
Beaver
Spring
36
603
595
661
640
672
667
660
643
640
1
2
3
4
5
6
7
8
9
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11
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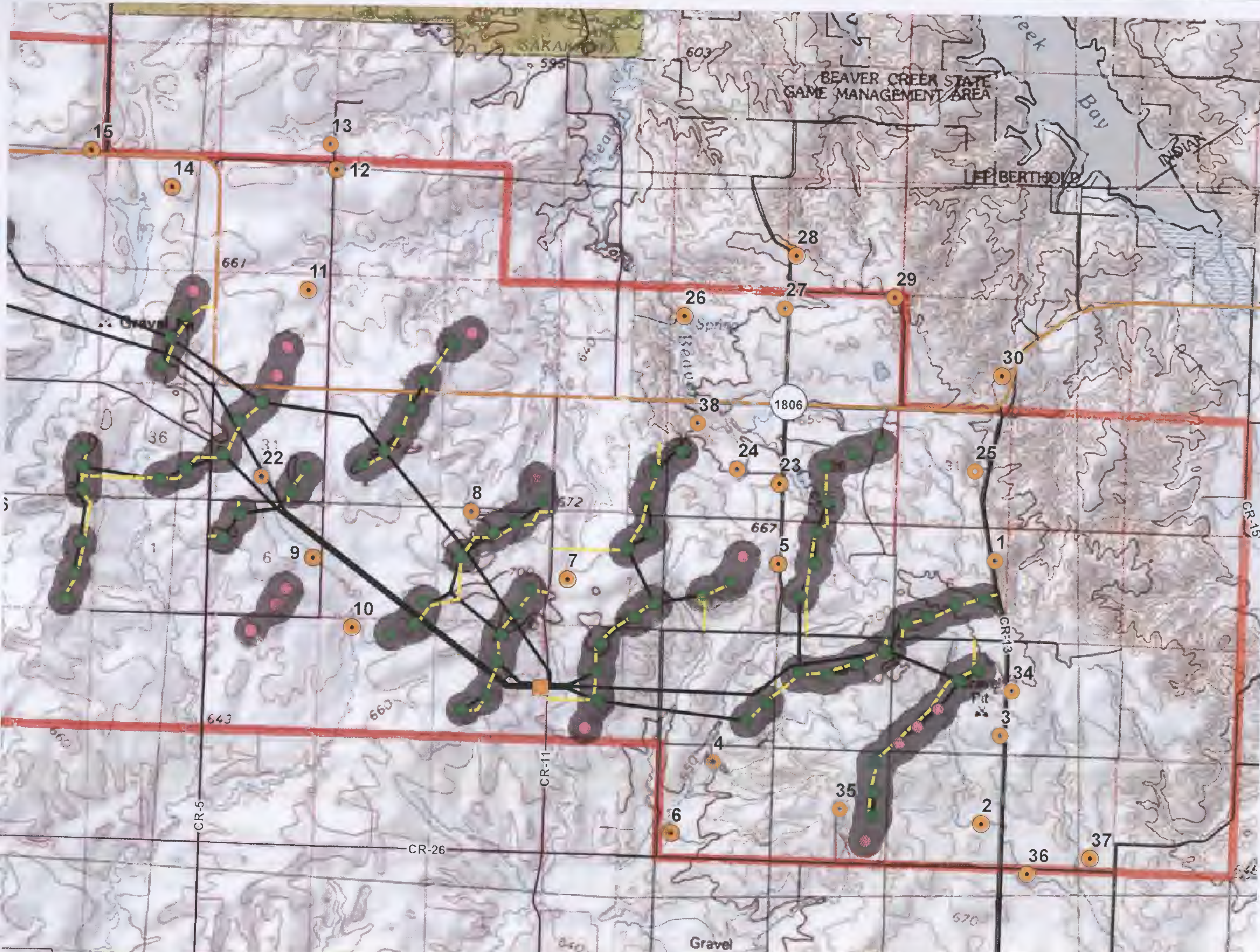
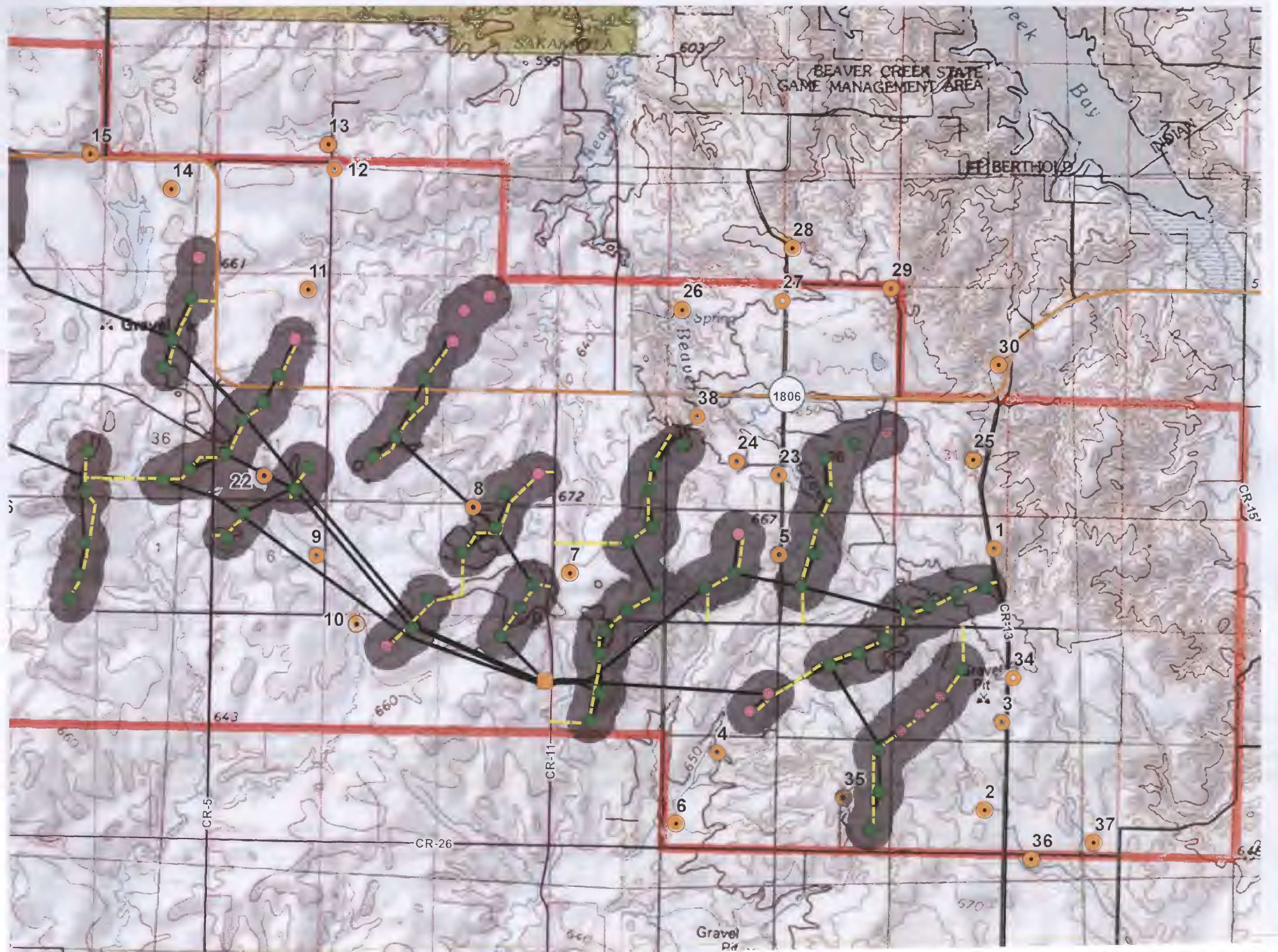
36
37
38



BEAVER CREEK STATE GAME MANAGEMENT AREA
LE BERTHOLD
CR-26
CR-5
CR-11
CR-13
CR-15
1806
Gravel Pit
Spring
Bay


BEAVER CREEK STATE GAME MANAGEMENT AREA
SAKAKAWEA
LE BERTHOLD
INDIAN
Bay
Beaver
Spring
Gravel Pit
Gravel
1806
CR-5
CR-11
CR-13
CR-15
CR-26
603
595
640
650
660
661
643
667
672
570
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
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23
24
25
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28
29
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34
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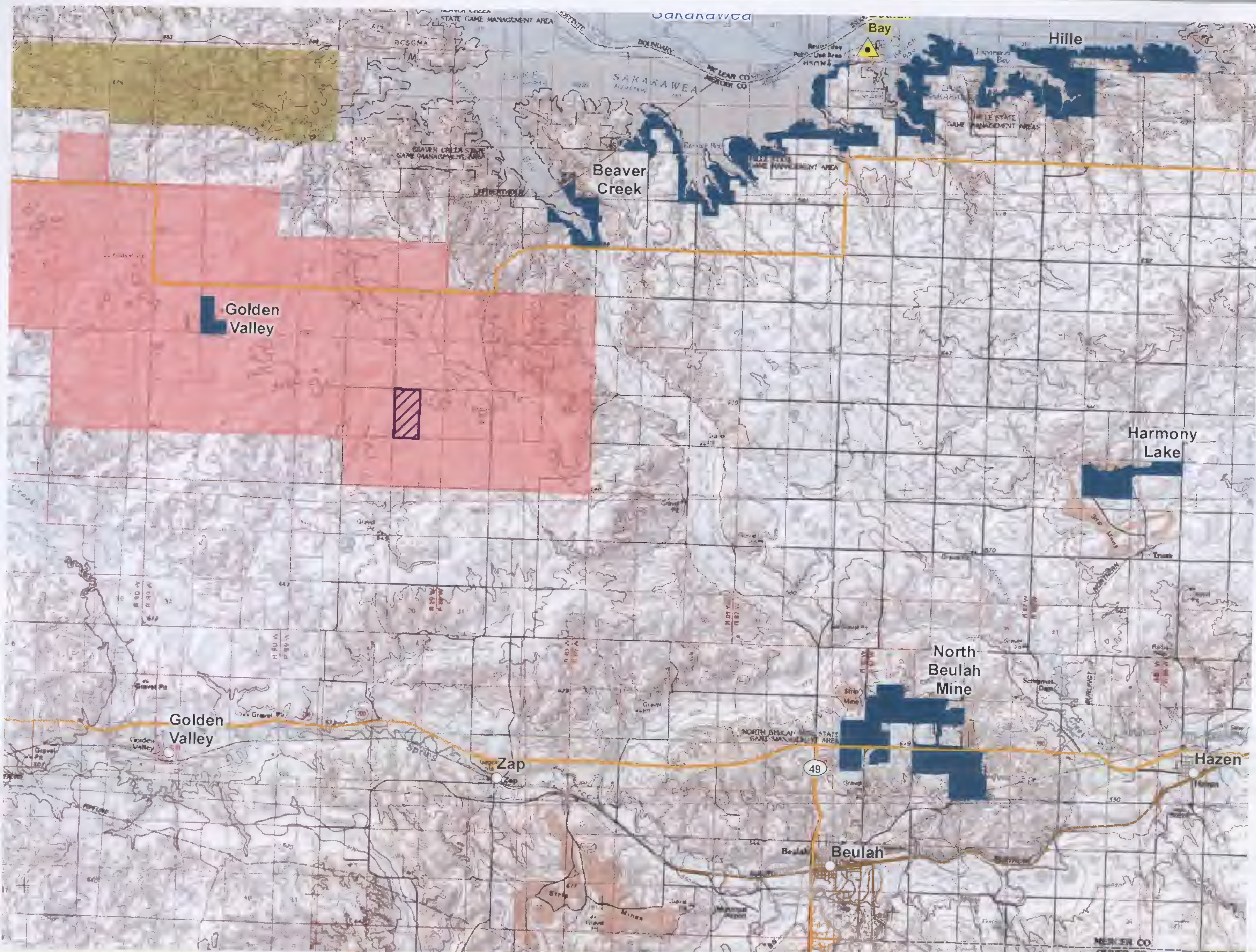
36
37
38


Bay
Hille
Beaver
Creek
Golden
Valley
Harmony
Lake
North
Beulah
Mine
Golden
Valley
Zap
49
Hazen
Beulah

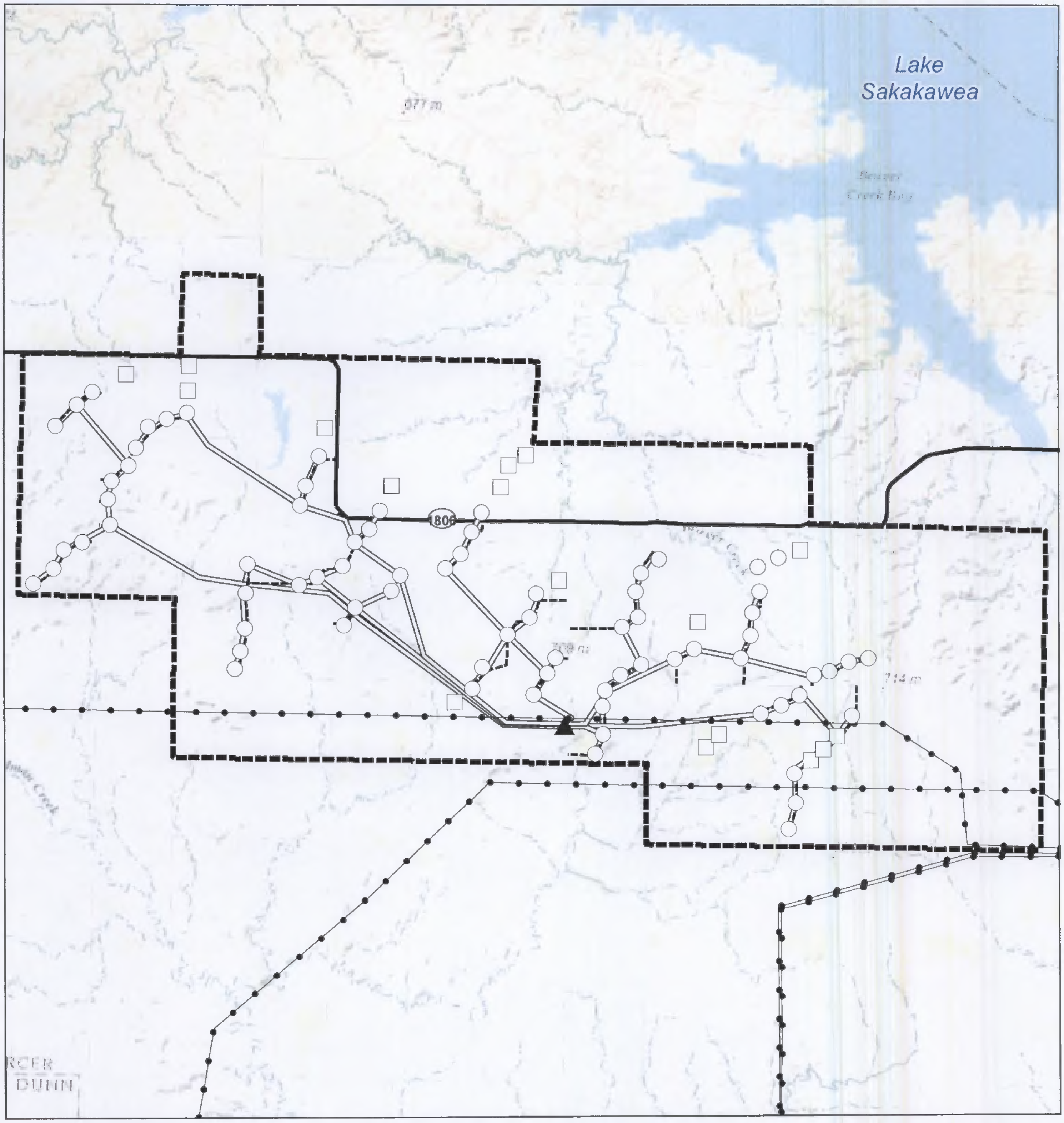


Figure 15A

Antelope Hills Wind Project Application for North Dakota Certificate of Site Compatibility

Project Layout Siemens 2.3-108

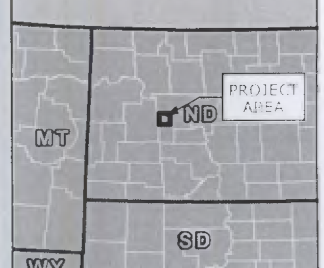
Mercer County, ND
Amended, October 2014

1:110,000 NAD_1983_StatePlane_North_Dakota_South_FIPS_3302_Feet

0 0.5 1 1.5 Miles

- Project Area
- Approximate Substation Location
- Turbine Location*
- Alternate Turbine Location*
- Approximate Access Road Routing
- Approximate Underground Collection System Routing
- State Highway
- Existing Transmission Line

*The Project would utilize up to 75 Siemens 2.3-108 turbines; however, 92 potential turbine locations are included on this figure to account for alternate locations that may be used.



TETRA TECH

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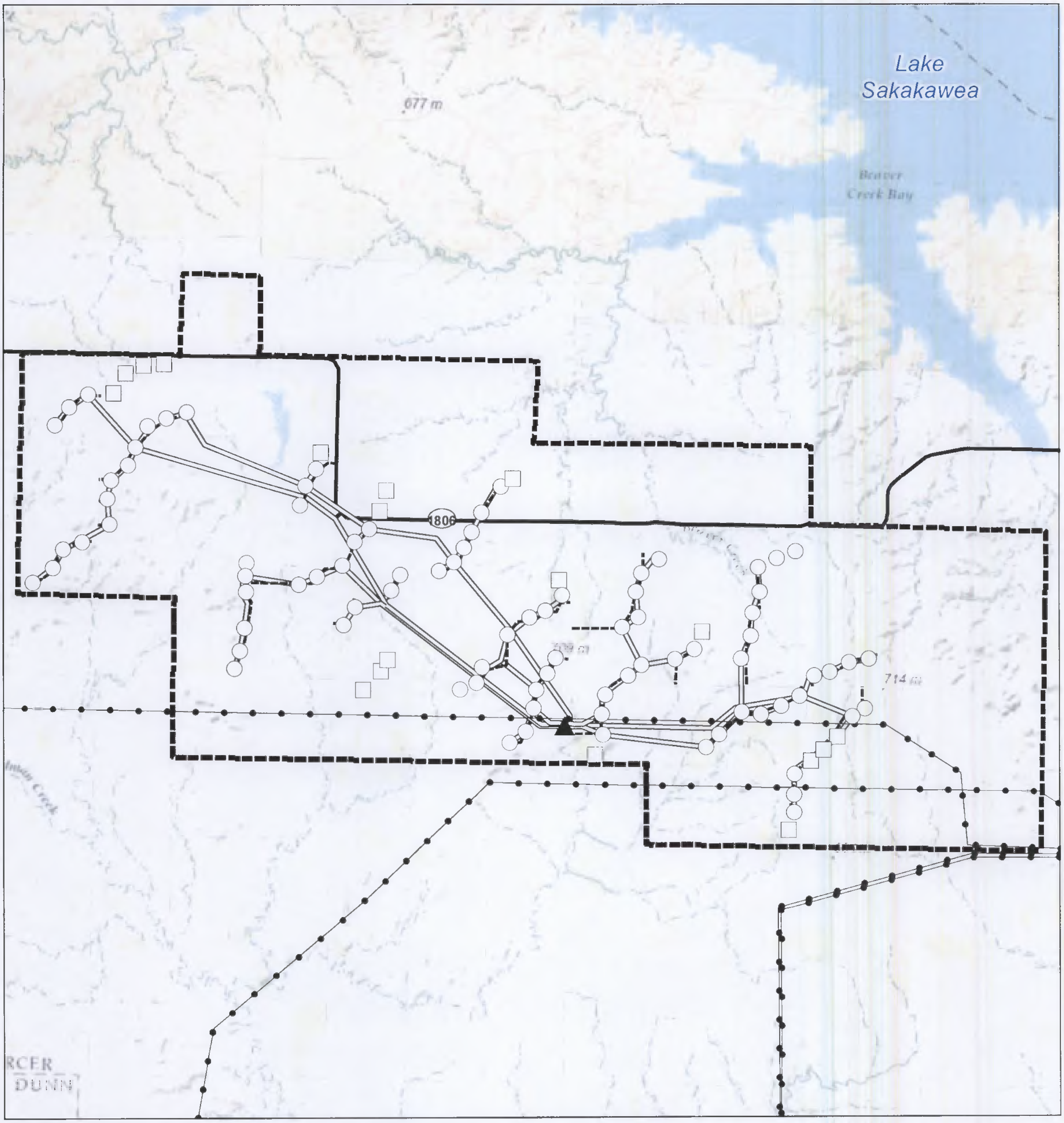


Figure 15B

Antelope Hills Wind Project
Application for North Dakota
Certificate of
Site Compatibility

Project Layout
Vestas V-100

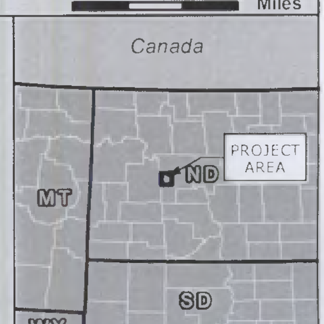
Mercer County, ND
Amended, October 2014

1:110,000 NAD_1983_StatePlane_North_Dakota_South_FIPS_3302_Feet

0 0.5 1 1.5 Miles

- Project Area
- Approximate Substation Location
- Turbine Location*
- Alternate Turbine Location*
- Approximate Access Road Routing
- Approximate Underground Collection System Routing
- State Highway
- Existing Transmission Line

*The Project would utilize up to 86 Vestas V-100 turbines; however, 105 potential turbine locations are included on this figure to account for alternate locations that may be used.



TETRA TECH

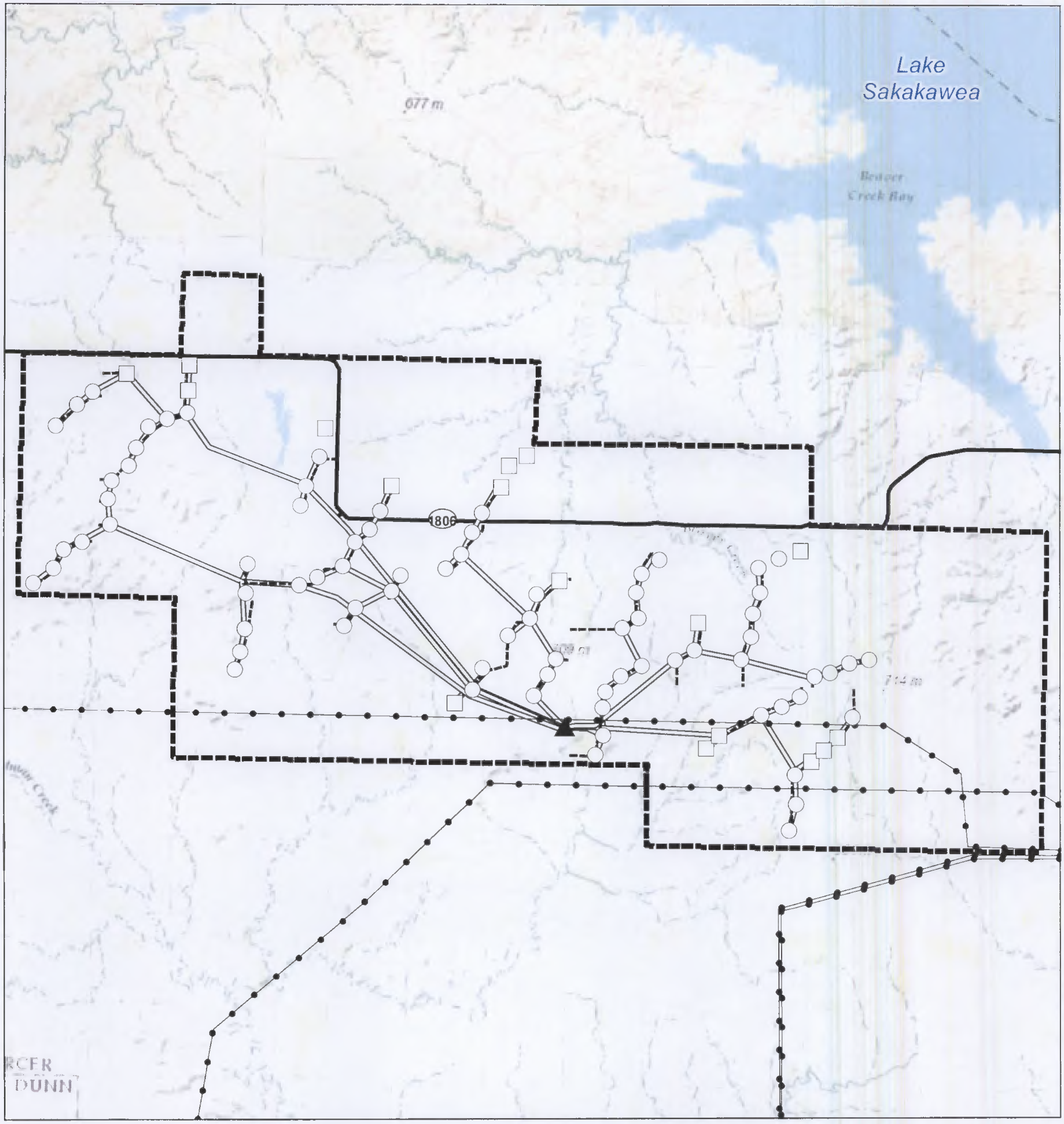


Figure 15C

Antelope Hills Wind Project
Application for North Dakota
Certificate of
Site Compatibility

Project Layout
Vestas V-110

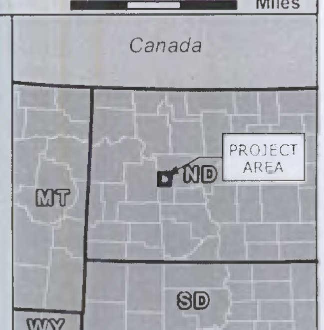
Mercer County, ND
Amended, October 2014

1:110,000 NAD_1983_StatePlane_North_Dakota_South_FIPS_3302_Feet

0 0.5 1 1.5 Miles

- Project Area
- Approximate Substation Location
- Turbine Location*
- Alternate Turbine Location*
- Approximate Access Road Routing
- Approximate Underground Collection System Routing
- State Highway
- Existing Transmission Line

*The Project would utilize up to 86 Vestas V-110 turbines; however, 92 potential turbine locations are included on this figure to account for alternate locations that may be used.



TETRA TECH

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